THE JULY SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

THE SCIENCE PRESS

LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

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Vol. XLIII, No. 1 July, 1936 Whole No. 250

The Scientific Monthly

An Illustrated Magazine Devoted to the Diffusion of Science

J. McKEEN CATTELL, Editor

WARE CATTELL, Associate Editor

Published by THE SCIENCE PRESS

LANCASTER, PA.—NEW YORK, N. Y., Grand Central Terminal—GARRISON, N. Y.

Single Number, 50 cents Yearly Subscription, $5.00

Entered as second-class matter at the post office at Lancaster, Pa., July 18, 1923, under the Act of March 3, 1879

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VOLUME XLIII
JULY TO DECEMBER

NEW YORK
THE SCIENCE PRESS
1936

THE SCIENCE PRESS PRINTING COMPANY
LANCASTER, PA.

THE SCIENTIFIC MONTHLY

JULY, 1936

THE EFFECT OF CIVILIZATION UPON THE LENGTH OF LIFE OF THE AMERICAN INDIAN

By Dr. CLARK WISSLER

CURATOR OF ANTHROPOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY

THE ways in which the illiterate peoples of the earth adjust their modes of life to the civilization of the white man is now the objective of many inquiries. The rising tide of white culture has all but engulfed them. As residents of the United States or Canada we are conscious of our surviving Indian tribes as little islands in this flood. We have been told that one by one these little clusters of aboriginal humanity are being drowned out, but this is an exaggeration, since few tribes have disappeared. The Indian's resistance has been by no means low, nor has he been entirely inept in adjusting himself to our rapidly changing economics.

Before the great depression set in we gave the Indians a neck-breaking race to keep in sight of us, but now they enjoy a breathing spell. For a long time we have pointed an accusing finger at them because they received food, clothing, etc., from the government, whereas now so large a part of our own population is dependent upon similar aid that it is the Indian's turn to call us to account for our extravagance and lack of initiative. However, the intent of this communication is to consider certain aspects of the Indian's struggle to keep in sight of white economic and social changes. It is this attempt of the Indian to work out his destiny that calls for investigation by students of social processes.

Most students of Indian acculturation have approached the subject from a psychological angle. They think of the Indian idling in his cabin, depressed over his degradation and poverty, whereas his standard of living is now far higher than his aboriginal ancestors enjoyed. Few Indians living in the United States today were born before reservations were established, so much of what Indians in general know of the old economic life is tradition rather than reality. Further, they are rapidly becoming bi-lingual and literate. True, they cherish many old forms and beliefs, but so do their white neighbors. The Indians now ride in automobiles, go to picture shows, use radios, etc. Nevertheless it is apparent that they are not saturated with our national culture but straggling in the rear. It remains to be seen whether if the reservation Indian is really depressed such unhappiness is due to his consciousness of maladjustment to white culture. Whatever may be the truth here, it is the social phenomenon so presented that has intrigued many students and which is to-day a subject of exploration by the U. S. Indian Service and social anthropologists.

Yet in all such studies the approach

has been almost wholly psychological and social, so it occurred to us that a biological approach might contribute something additional to an understanding of the situation. The average reservation group of Indians is a community of about a thousand persons, and if we fix our attention upon this mass of living humanity, whose individuals are constantly changing through age, birth and death, we begin to be curious as to how these biological groups stand up under the impact of civilization. A guess might be that when first put upon reservations the strain of adjustment was greatest. Death and disease might then take the greatest toll, but as the Indian gained in his efforts to adjust his mode of life to new conditions, the losses would decrease. In other words, a history of death, birth, disease, etc., would be the first consideration.

For such a study one needs good statistics. Preliminary exploration convinced us that the Canadian Indian Department possessed the most accurate data, but that those for United States Indians, though less satisfactory, were usable. Accordingly we chose the Indians of the Northern Plains as a test group—the Western Cree, Assiniboin, Gros Ventre (Atsina), Blackfoot, Blood, Piegan and Sarsi. These tribes are now living in Alberta, Saskatchewan and Montana. They reside on seventy reservations, administered under nineteen agencies. Seventy-four bands or social divisions are recognized, each of which occupies definite reserve lands and the population data for which are recorded separately. For this study we have used the totals for the respective tribal groups.

The data were tabulated by Mrs. R. A. Sanderson, honorary life member, American Museum of Natural History.

Population History

Our first concern is with the gross population history of these tribes. Table I shows that these Indians began reservation life with a population somewhat greater than they now have, but that the low point was reached about 1904. We think this means that for a time the strain of reservation life was great, but that eventually a turning point was reached.

Such a gain in population might be brought about by an increase in the birth rate, a decline in the death rate, or both. So we next sought for data on births and deaths. The birth rates were compiled for these separate reservations, showing approximately 42 per thousand population for the whole group of tribes between 1884 and 1934 (Table I). The rate was tabulated annually and the rate of 42 is an average per five-year intervals. The interesting point is that the rate is constant and probably is the same as the birth rate of these Indians in pre-reservation days.[1] In other words, whatever the impact of white culture upon the physiology of these Indians, the reproductive function resisted effectively. Then, naturally, if population rose and fell with a constant birth rate, we must look to the death rate for an explanation. Incidentally we remark that 42 is a high birth rate, perhaps near the physiological maximum.

TABLE I

Population Changes in the Reservation Period

	1884	1904	1934
Population	22,281	14,645	19,536
Birth rate	42	42	42
Death rate	70*	52	33

* Estimated.

Indian death rates were found highly variable. They vary also as between reservations. The highest rate for any year was 100; the lowest, 27. Our tables suggest that the lowest level of population was reached about 1904, but the total death rates after reaching a maximum peak about 1892 declined gradually to the present.

[1] Ferguson reports a similar constant rate for certain Cree reservations. Wissler, *Proc. Nat. Acad. Sci.*, Vol. 22, No. 3, 1936.

Thus we find the death rate seemingly sensitive to the impact of reservation life. Yet the trend has been steadily downward from early reservation days, and though still much higher than the white rates for corresponding regions, we have good ground for predicting that eventually it will drop to the white level. Should the birth rate remain high, Indians will then become conspicuous in our population, because each downward step in the death rate would further accentuate population growth.

When these Indians were first placed upon reservations, disease took a heavy toll. The inclination has been to explain this as due to a depressed and discouraged state of mind. This was a factor, but when people are thrown together in a new way, as in concentration camps, there is a rapid rise in disease. Placing these Indians upon reservations was analogous to a system of concentration camps and the government reports show that measles, colds, diphtheria, pneumonia, etc., soon appeared, just as in a military camp for recruits. Hence, there seems no reason for assuming mental and emotional distractions as the chief causes for the high death rates. We note, then, that a few years after these Indians had been placed on reservations, the death rates turned downwards, this trend persisting to the present.

However, officials in charge of reservations regard their job as not complete until the death rates for the Indians under their care approximate those among the surrounding white population. They have implicit faith that when these Indians come to live like white people their death rates will approximate those of their white neighbors. This expectation may not be fully realized, but our studies suggest that it will be approximated.

The reservation records show that changes in housing, clothing, food, etc., were progressive throughout the period 1880 to 1935. The standards were set by the changing white culture, hence the foregoing means that these Indians were progressively adjusting themselves to white modes of life. The significant observation is that since the initial shock of reservation life, the continued fall of the death rate has been coincident with progressive changes in the mode of life.

Minors and Adults

Students of population know that the hazards of life often vary with the age of the individual, and it has been observed that the death rates for age classes vary. The early records for the Indians studied recorded individuals by sex and classified them as minors and adults. This enables us to observe what happened to these classes in the population as the mode of life changed. If reservation life bore hardest upon minors, their numbers should decrease relatively.

TABLE II

Minors and Adults Among the Cree Indians Per Thousand Population

	1894	1914	1934
Adults	564	475	467
Minors	436	525	533

First we note the relative numbers of minors and adults among the Cree Indians (Table II). In 1894 there were more adults than minors, but the relation is reversed in 1934. Our data for other tribes indicate the tendency to be for minors to increase from year to year after the beginning of reservation life. Such a relative increase suggests that the death rate for minors is falling. The death rate for adults is falling, too, but obviously at a much slower pace. We see, then, that reservation life is becoming relatively more and more favorable to minors.

The reservation records for later years group populations under five arbitrary age periods, as in Table III. Tabulating these data, we find that age groups 0–5, 6–15 and 65 + are increasing; 16–20 and

TABLE III
TREND IN AGE GROUPS PER THOUSAND POPULATION FOR THREE TRIBES—MALES

Ages	1900	1934
0– 5	78	98
6–15	99	106
16–20	55	47
21–64	240	231
65+	19	24

21–64 decline. We observed this decline to be regular and the same relatively for each tribe. Thus even small differences became significant.

Recalling that minors as a whole increased relatively we see that what actually happened was that the children of ages 0–15 increased relatively, whereas persons 16–64 years decreased. This is to say that reservation life was favorable to the survival of children 0–15 years of age and increasingly so; also favorable to those of 65+. On the other hand, the same mode of life bore hard upon individuals 16 years and over. We should, then, like to know whether more Indians died during the period 16–20 than later. Had we data for the ages of death the solution would be easy.

CHANGES IN SEX RATIOS

So much for age classes; we now turn to sex grouping. The first explorers in the northern plains noted the unusual excess of women; no count was necessary to reveal the male minority. In 1809 Alexander Henry, the head of a fur-trading company, made a census of the tribes we are considering with the following result: 4,823 men, 13,632 women, 45,906 minors. We know nothing as to how this count was made, but the potential consumption and production of the various tribes was of first importance to the trade. Any one reading Henry's journal will be impressed by his painstaking accuracy in all the affairs of life. Reducing Henry's figures to relative terms there were approximately 74 men, 212 women and 714 minors in a thousand population. As a test, we found that among a division of the Cree Indians in 1904 there were 177 men, 212 women and 611 minors per thousand population. This is the highest rato for minors observed by us, but other tribal groups approach it, so there is nothing improbable in Henry's census of 1809. In 1904 men were more than twice as numerous as in 1809. Should our 1904 population have had a similar small number of males, the number of minors would have been as great as in 1809. For example, if in 1904 the men were reduced to 74 per thousand, assuming that the others were killed in hunting and war and that there were no such losses among women, then the case would stand as in 1809. So the differences between 1809 and 1904 are not distressing. Where the taking of more than one wife is good form, the number of wives per man is entirely dependent upon the number of women.

In the previous section we noted that on reservations the trend has been toward an equality and eventually an excess of minors over adults. Such might be expected with a constant birth rate, if the relative number of males increased. So we turn directly to the relative number of men and women. There is some evidence that when these Indians were placed upon reservations women were still in the majority.

TABLE IV
TOTAL RATIO FOR TRIBES STUDIED

	1894	1934
Men	246	248
Women	326	232

Since reservations were established about 1880, it is assumed that then women were more numerous than in 1894. Even if the causes resulting in more women than men ceased to operate in 1880 the survival of women would easily account for a declining excess, or the observed trend. Taking 1809 as the starting point with 76 men per thousand the suggestion is that by 1894 the relative number of men had risen to approxi-

mately one fourth of the population, but there was still an excess of women; however, in 1934 the women were slightly in the minority. So as a general proposition we can say that in aboriginal times men were in the minority, but that reservation life inaugurated a trend toward equality and eventually to an excess of males.

Naturally the question arises as to the causes for such changes. There are at least two possibilities; more females may have been born or the death rate for males may have been abnormally high. We have no data on the sex birth-ratio for the tribes studied, but among a Dakota Indian community in the United States the ratio is about 106 males to 100 females. This is similar to United States white and other national ratios. We can, however, shift our approach to the sex ratios for age classes. In respect to minors we note that for the Cree Indians the sex ratios of minors are comparable, as:

TABLE V
SEX RATIOS OF MINORS

	1904	1919	1929
Male	249	268	253
Female ...	249	266	258

On the other hand, female adults exceeded males by about 15, 14 and 10 per cent., respectively. This would seem to suggest that the relative loss of males was not conspicuous before twenty years of age.

However, for two Cree reserves at Carlton, Canada, we have data for an age grouping. These reserves are still conspicuous for their continued excess of women. The peculiarity, however, is that males begin to fall behind after the age of sixteen years. Further, we had data for calculating the death rates in this group by sex, minors and adults. The average rates per thousand for the period 1899–1932 were:

Boys	34
Girls	22
Men	15
Women	16

Inspection of the data indicates that the heavy losses among males come just after sixteen and return to normal at about twenty-five. Thus some hazard besets males between the ages of 16 and 25.

The most direct approach to an understanding of this loss of males would be a study upon the ground, but that is impractical at present. Anyway we believe the answer can be had from the data at hand.

WOOD CREE

If our assumption that these observed trends are due to modes of life is justifiable, then wide culture differences between Indian reservations should also register in population distinctions. The Indians represented in Table VI are known as Wood Cree and Plains Cree. A century or two ago all these Cree were Wood Cree, living chiefly on the edges of the plains but gradually drifting out into the open plains. When located on reservations, the lands assigned the Cree were on the edges of the plains, near the transition forest zone. Those now called Wood Cree had not wholly taken to plains life when the reservation period opened. The true Plains Cree could no longer kill buffalo, so they were given rations. On the other hand, the Wood Cree could still support themselves in part by hunting and trapping in the adjoining forests and have so continued to this day. So, in brief, there is a wide difference between the modes of economic life followed by the two divisions of Cree. Table VI shows the population differences between them. In number of minors Wood Cree lead; they have a marked excess of women over men; their birth rate is the same as other Indians, but the total death rate is lower. However, the exceptional Carlton death rate for minor males, and the lower number of males for the age group 16–20, occur in a division classed as Wood Cree.

In an earlier paragraph we noted that the age group 16–20 was diminishing

relatively among all Plains Indian groups; there was practically no difference between males and females. Yet for the Carlton group the number of males in the 16–20 group was decidedly lower than females. This is consistent with the high death rate for all Carlton male minors. We think it safe to conclude that the sudden loss of males occurs at this time.

As stated, these Wood Cree males engage in trapping and hunting, especially the adolescents and young adults. The hazards in such a life are great. The officials in charge of these reserves report that many male lives are lost from undue exposure and accidents incident to trapping excursions. We see, then, an occupational hazard and one which could have operated in aboriginal times. If we add the hazards of the war trail in pre-reservation days, the scarcity of men in the census of 1809 is not surprising. However, all such effects are directly traceable to social or cultural factors, and so it is the mode of life which contributes to such changes in population among the Indian tribes we have studied.

TABLE VI
WOOD AND PLAINS CREE

	Wood Cree				Plains Cree			
	Minors		Adults		Minors		Adults	
	M.	F.	M.	F.	M.	F.	M.	F.
1909 .	254	280	211	255	241	248	241	270
1919 .	273	300	198	229	241	248	246	265
1934 .	238	283	222	257	263	267	233	237

AGE-AT-DEATH PROFILES

Population statistics for civilized countries present tables recording age-at-death, and the plotting of such frequencies gives interesting profiles. Clements[2] first called attention to some wide differences between such profiles for Indians, Negroes and whites.

These differences result from variations in the death rates for the respective age groups. Though for the Indian reservations studied by us there were no records of deaths, yet we noticed that when living Indians were classified according to age, the frequencies were different from either white or Negro. For Indians we found that there were definite trends in age grouping. On the whole they seemed to be approaching the white people, though slowly. So we came to suspect that as these Indians approach equality with whites in most of the details of living, their age-at-death profiles will approximate those of the white population living around their reservations. If so, the form of the profile will vary with the mode of life and doubts arise as to the existence of race differences in such profiles. It seems fair to assume, then, that age-at-death profiles are not constant but reflect changes in mode of life.

The quantity of Indian data available is hardly sufficient for a fair test of this assumption, but if the principle holds, it should follow that wide differences among white and Negro communities should register in their age-at-death profiles. So we turned to the United States census.

We chose Ohio and Louisiana as random samples of white population. Limiting our experiment to what the census classes as rural populations, we have profiles as in Fig. 1. While these profiles have similarities, there are real differences. For most of the states similar age-at-death tables for whites are given in the census, between many of which there are conspicuous differences. We think it is a reasonable assumption that these differences are due to differences in the social factors making up the complex we call the mode of life.

Next we sampled the census tabulation of Negro deaths. This revealed regional differences, illustrated in Fig. 1. Again using Ohio and Louisiana as samples we observed that the Negro profiles differ from each other even more than did the white profiles. Again Negro and white

[2] F. Clements, *Human Biology*, 3: 397–419, 1931.

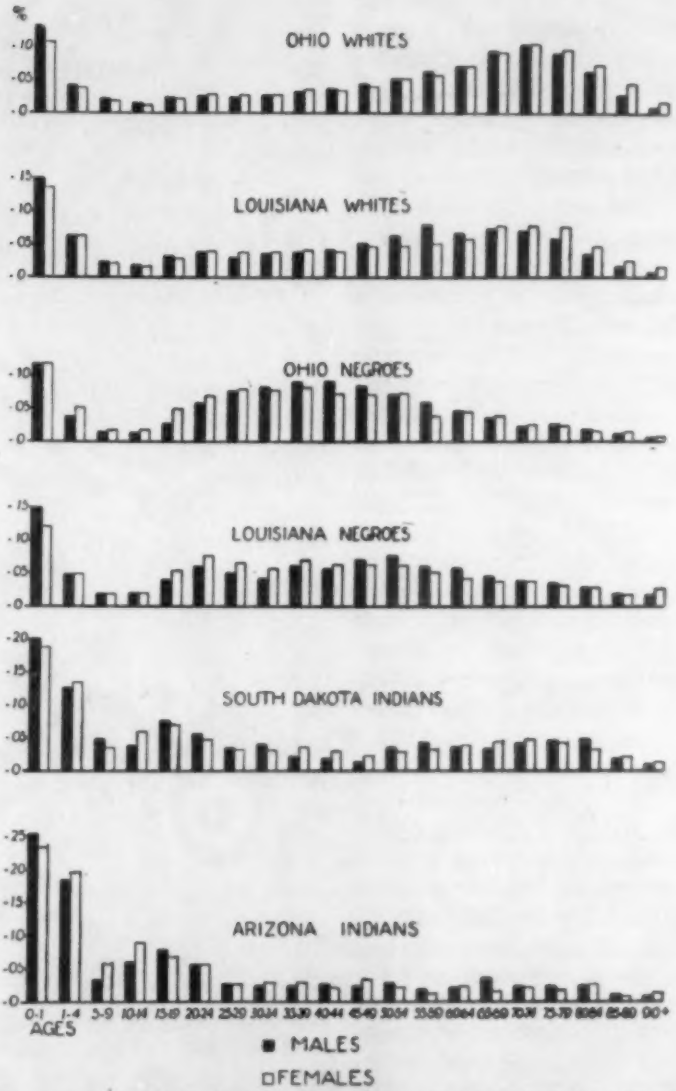

FIG. 1. AGE-AT-DEATH FREQUENCIES FOR WHITE, NEGRO AND INDIAN GROUPS IN DIFFERING ENVIRONMENTS

THE DATA ARE FROM THE UNITED STATES BUREAU OF THE CENSUS, MORTALITY STATISTICS, 1928; TWENTY-NINTH ANNUAL REPORT, WASHINGTON, 1930. COMPILED BY MRS. R. D. SANDERSON, HONORARY LIFE MEMBER, AMERICAN MUSEUM OF NATURAL HISTORY.

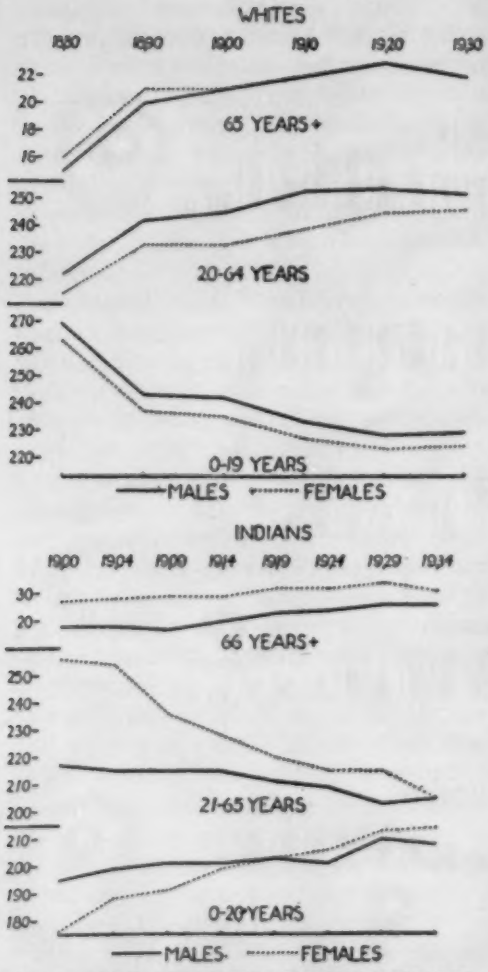

FIG. 2. AGE GROUPING PER THOUSAND POPULATION FOR INDIANS AND WHITES

NOTE THAT THE INDIAN AGE GROUP 0–20 GAINS, WHEREAS AMONG WHITES THE GROUP 0–19 DECLINES. ADULTS DECLINE AMONG INDIANS BUT GAIN AMONG WHITES. THE ELDERLY GROUPS GAIN IN BOTH. SEX DIFFERENCES ARE CONSPICUOUS; MALES EXCEED AMONG WHITES, FEMALES AMONG INDIANS. THE INDIAN DATA ARE FOR ALBERTA AND SASKATCHEWAN, CANADA, AND THE WHITE DATA FROM THE UNITED STATES CENSUS.

differ in each case. We tabulated Negro data for a number of states; Pennsylvania, Illinois, Wisconsin, California and the State of Washington presented the Ohio form of profile, Mississippi and Georgia a profile like that for Louisiana. As a further test we tried Negroes in Oklahoma, Kentucky and Maryland, finding their profiles intermediate to Louisiana and Ohio.

The result of this experiment was satisfactory. The differences are real enough. We assumed that the total complex called "mode of life," in Ohio, for example, is not the same for white and Negro, nor is it quite the same as for whites and Negroes in Louisiana. Further, we doubt if any one would expect the mode of life followed by Negroes in Ohio to be precisely like that of Negroes in Louisiana.

It was not our intention to analyze these local white and Negro populations with a view to isolating the causes of the observed differences. Our problem lies with the Indian. However, if it is proposed that migration, inaccuracy in age, early marriage, birth control, education, etc., account for the differences, our initial assumption stands, since these are all social factors embraced in the mode of life. Again, the reader may feel that we have not given disease its due. We do not claim that all deaths are due to mode of life, that would be absurd, but it seems probable that the number of young people dying between 15 and 25 years, for example, will vary greatly with the mode of life. The contrasts in infant mortality between civilized and primitive peoples have long been recognized; the very high rate among primitive peoples is attributed to their mode of life. Disease may well be something apart from mode of life, but the number of persons stricken and the number that die seem to vary with the social behavior of the group.

The data for American Indians make it clear that the age-at-death curve has changed as the mode of life changed. The birth rates for the tribes we have studied remained stubbornly constant from the day they were forced to give up their free life and settle down upon reservations. The life upon reservations

called for a rapid change in mode of life; we find coincident changes in the death rates. Until recent years there were no reliable data for age-at-death ratios, but there were indirect data showing that the age-at-death ratios must have changed progressively.

From the census we compiled Indian deaths for Arizona and South Dakota. These Indians do not live under the same conditions, and their original modes of life were widely divergent. Differences appear in their profiles, Fig. 1. Further, we found the profiles for the Indians of North Dakota, Washington, California and Ontario closely similar to South Dakota. On the other hand, New Mexico, Wisconsin and Alberta resembled the profile for Arizona.

We have, perhaps, carried these illustrations far enough to support the assumption that the age-at-death sex profiles are sensitive to modes of life, including whatever other factors influence the survival of the individual. However, it can be demonstrated that all Negro communities in the United States have some social factors in common, so have white communities and Indian tribes in the United States and Canada, which is consistent with some apparent general differences between white, Negro and Indian profiles. On the other hand, the wide differences within these race groups is consistent with the conclusion that these differences are not constant and chiefly dependent upon the mode of life.

Résumé

We have briefly explored such vital statistics as were available respecting certain Indians living upon reservations and in process of acquiring the modes of life pertaining to the surrounding white population. We noted that the population profiles for these Indians were determined by varying death rates for sex and age groups. The marked excess of women we found due to exceptional occupational hazards for men, to which in pre-reservation days were added the hazards of predatory warfare. On reservations where occupations are now similar to those of rural whites we find Indian women and men now approximately equal. Age grouping revealed progressive changes among both males and females. The death rates for such groups showed changes coincident with changes in modes of life. In other words, the population profile was found sensitive to social changes in the group. A comparison of such profiles would then indicate roughly similarities in modes of life. We conceived the mode of life as a complex of practices favorable, neutral and unfavorable to the survival of the individual. The population profile would be the resultant of all factors operating, social and otherwise. The evidence so far suggests that the crude death rates for two tribes of Indians might be equal, but numerous variations in their modes of life result in distinct population profiles.

The social sciences have now become interested in observing how such formerly primitive groups as Indians adjust their modes of life to white culture. The process of becoming a white man is often spoken of as acculturation. The Bureau of Indian Affairs in Washington is now in need of a method by which reservations can be classified according to the degree of acculturation attained. The suggestion made here is that an improved system for recording vital statistics will furnish one index to acculturation.

THE INFLUENCE OF THE SUN ON HUMAN AFFAIRS

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THE study of the effects of the sun on affairs on the earth opens many interesting possibilities. Aside from the more obvious changes that take place as the result of seasonal variations in the amount of sunshine, there are changes going on in the sun itself which may have far-reaching counterparts in terrestrial affairs.

Probably every one is aware that there is a more or less definite cycle of about 11¼ years through which the sun passes from one disturbed condition to another. Whatever the effect of these physical alterations in the sun's behavior may be, and whatever may be their ultimate cause, they are marked by the observation of hurricanes in the solar atmosphere; hurricanes that would make the most violent of our tropical disturbances appear insignificant in comparison. The storms consist of vortical whirls raging on either side of the sun's equator. Clouds of hydrogen, calcium and the vapors of other elements spiral about in a clockwise or counter-clockwise direction, attended by violent currents in the solar atmosphere. In the heart of these stormy areas the temperature is sufficiently lowered to produce an appreciable darkening in the brilliancy of the solar surface, as seen through a telescope. These darkened areas which appear by contrast as black spots have been known as sun-spots as far back as the invention of the telescope in the early seventeenth century. Even prior to the telescope era disturbances of this character had occurred of such huge dimensions as to be recorded in certain instances by the naked eye, probably during the sunrise or sunset hours when the earth's atmosphere screens the harmful rays and allows one to see the reddened disk of the sun with the unprotected eye.

Systematic observations of sun-spots have been made for more than 300 years so that the definite rise from minimum to maximum in the numbers of these spots has been well established for at least some 20 cycles. The last period of maximum disturbances occurred during the years 1928–29, July 1, 1928, being the approximate middle date marking the top of the last maximum of the sun-spot curve. The autumn of 1929 showed a large drop in the number of sun-spots which, incidentally, can be remembered by the season of a rapid fall in certain terrestrial markets. Sun-spots continued to decrease until they reached a minimum in September, 1933. Since that time, they have been definitely increasing and during the last year have gained rapidly in numbers and in size.

The so-called "sun-spot number" is a characteristic figure derived from observation and takes into consideration not only the actual number of spots but the number of the groups of spots as well. To reconcile the results of telescopes of various apertures a coefficient is introduced into the formula for deriving the sun-spot number of a given date. One characteristic in the development of the sun-spot cycle concerns the position of these spots on the sun's surface. The disturbances invariably break out at relatively high latitudes on the sun. With the progress of the cycle the spots increase in number in both hemispheres and at increasingly lower latitudes until the maximum is reached in the neighborhood of solar latitude 20° either side of

the equator. Thereafter the spots decrease until the few survivors vanish within 4° or 5° of the solar equator. Almost never are spots seen higher than the latitude 40° or within less than 5° of the equator.

Watching the spots for a few days in succession will reveal to one that they drift across the solar disk, showing that the sun rotates on an axis. From the motion of the spots it is found that the sun's axis is inclined to the plane of the earth's orbit some 7°. In June and December the earth is in the plane of the sun's equator. Early in September the north end of the sun's axis is tipped 7° towards the earth and, therefore, spots in the northern hemisphere of the sun having latitudes of this amount may pass directly in a line with the earth. Similar circumstances occur for the other hemisphere of the sun six months later. This has an important bearing on the question of the effects of sun-spots on the earth, since there is some evidence for believing electrically charged particles may be propelled from sun-spots toward the earth when they are suitably located. A point on the solar equator is carried completely around the sun with respect to the earth in just 27.3 days. At higher latitudes the sun rotates more slowly, and near the poles some 35 days are required for one rotation. This, of course, shows that the solar surface consists of a luminous gaseous atmosphere. The difference in rotation at different latitudes causes, therefore, a shearing or dragging effect in the different zones which is most conducive to causing cyclonic whirling in the region of sun-spot zones.

All sorts of fantastic calamities on the earth have been blamed on sun-spots. Droughts, floods, hurricanes, the productivity of fur-bearing animals and the weather, even economic depressions have all come in for their share of correlation with solar phenomena. Whether or not there is any scientific basis for presuming such intimate relationship between the sun and the earth, the most conservative scientists are agreed that the characteristics of the mysterious earth's magnetic field change step by step with the sun-spot cycle. More than 200 years of observations of the earth's magnetic activity, as is evidenced by the wandering of a compass needle, substantiates beyond doubt that magnetic disturbances on the earth accompany these solar disturbances that we call sun-spots. Not, however, until early in the present century did we have any clue either from the solar or from the terrestrial end as to why such a connection should be evidenced.

It was in 1908 that Dr. George E. Hale, founder and first director of the Mount Wilson Observatory, announced the true cyclonic character of sun-spot disturbances. As soon as it was evident that hot solar gases were whirling at terrific velocities about the sun-spot centers, it could be seen that if such gases were ionized or carried electrically charged particles, then huge currents of electricity must be flowing around the vortex creating a magnetic field within the sun-spot itself. Confirmation of this hypothesis came about through the brilliant demonstration of the changes in the frequency of the light waves emanating from the vicinity of sun-spots. It was in 1896 that Zeemann showed in the laboratory the effect of the magnetic field upon the behavior of light. Hale found the identical effect in the light from sun-spots, thereby showing unmistakably that the sun-spots in themselves were centers of powerful magnetic fields many times stronger than the magnetic field of the earth. Thus, from the solar end came the first clue as to the cause of magnetic changes in the earth accompanying the occurrence of great sun-spot outbreaks.

The second clue, this time one from the earth end of the chain, came about through the advent of the radio. In the

early days of wireless transmission it was thought that these electromagnetic waves traveled in straight lines and therefore could not be picked up at great distances on account of the curvature of the earth. Only by building higher and higher antenna towers was it thought possible to increase the range of wireless communication by the early experimenters. However, some observers thousands of miles from the original wireless stations were eavesdropping and heard signals from the distant towers that were well beyond the limit forbidden by theory. Since observation is the last court of appeal in science it is obvious that the theory of wireless transmission had to be revised.

It was then that Professor A. E. Kennelly of Harvard ventured the hypothesis that the upper layers of the earth's atmosphere were electrified or ionized by the sun's radiation falling on it and formed a conducting, and hence an excellent reflecting shell, for turning back toward the earth the wireless waves which had ascended skyward. The English scientist, Heaviside, was seized with the same idea at about the same time and made a similar announcement a short time after that of Dr. Kennelly. In honor to the imagination of these gentlemen, radio technicians to-day refer to the ionized strata in the earth's atmosphere as the Kennelly-Heaviside Layer.

With the advent of radio broadcasting stations for the public benefit, a new tool was now in the hands of the scientist for investigating new changes in the electrical state of the upper atmosphere. Austin, Pickard, Appleton and others, including the author, became interested in systematic measurements of intensity of the carrier waves sent out from broadcasting stations to see if by any chance long periods of fading or increasing intensity might not show some correlation with solar phenomena. By the time of the sun-spot maximum of the years 1928–29, sufficiently quantitative results were in hand to prove beyond much doubt that the ionization or electrical condition of the earth's upper atmosphere responded promptly to the outbreak or decrease of sun-spots. Combining the knowledge gained from the magnetic character of the sun-spots themselves and the knowledge of the electrical condition of the earth's atmosphere obtained through radio measurements, it becomes possible to see how magnetic changes in the earth follow solar disturbances. The magnetic field of the earth is due partly to a kind of sub-permanent magnetism, apparently hidden within the earth itself, which accounts for the north magnetic pole some 1,400 miles from the true geographical pole. It is also partly due to the magnetic effect of the electrified shell of the earth's atmosphere in rotation about the true geographical pole as the earth turns on its axis. The combination of these effects may well account for the diurnal variation in the direction of the compass observed at all magnetic observatories. Anything then which disturbs or changes the degree of ionization or the number of charged particles in this electrified shell of the earth's atmosphere will alter the amount of magnetism induced in the earth through the rotation of this shell.

If we may suppose that electrons or other charged particles are ejected from the sun's surface, then in the vicinity of sun-spots they would tend to stream away radially through the center of the spot guided by the electromagnetic field created by the spot itself. When sun-spots are near the sun-earth line, we should expect the most marked effect on the magnetic changes on the earth. From careful study of great magnetic disturbances between the years 1875 and 1903, Maunder was able to show that the sudden commencement of such disturbances in every case corresponded to the passing of a large spot near the central meridian of the sun. The average time

elapsing between the meridian passage of a spot and the commencement of the corresponding magnetic disturbance on the earth has been found to be about 30 hours. During these magnetic disturbances on the earth we witness unusually brilliant displays of aurorae. A Norwegian scientist, Dr. Störmer, has shown that the gorgeous displays of the northern lights could be well accounted for on the supposition that electrified particles are entering the earth's atmosphere at such times in unusual quantities. Deflected by the earth's magnetic field these streams of particles tend to converge in the neighborhood of the north pole, thus increasing the ionization of the earth's upper atmosphere in that neighborhood, causing incandescence or illumination similar to that caused by the cathode rays streaming through a vacuum tube similar to that employed for x-ray examinations. The greater frequency of auroral displays at sun-spot maxima appears to be an argument for the emission of charged particles from the sun directed earthwards by the magnetic fields of sun-spots.

Some scientists attribute the increased ionization of the earth's upper atmosphere to an increase in the ultra-violet light of the sun, which is presumed to take place with a general increase in solar activity. Observations by the author, however, would seem to show that changes in radio reception follow more closely the outbreak of spots in the central region of the sun than a change in the intensity of the ultra-violet light from the sun as has been measured during the last decade. Furthermore, if the curve showing changes in the intensity of radio reception plotted against the occurrence of sun-spots in the central zone of the sun, and therefore near the sun-earth line, be compared with a similar plot based on the number of sun-spots seen on the whole disk of the sun for the same years, it becomes evident that the changes in radio intensity follow much more closely the curve of sun-spots in the central zone. This, then, seems to argue for a true sun-spot effect in explaining the disturbances in the ionosphere that affect radio reception.

From time to time various reports appear to indicate that there is a close correspondence with the character of radio reception and changes in the weather. The presence of a "high" or a "low" of barometric pressure appears to have considerable influence on both the intensity and the direction of the radio wave propagated from a given broadcast station. If, as appears to be the case, we have definitely established a relation between the behavior of radio reception and the occurrence of sun-spots, and if it should become substantiated that there is direct relation between changes in the weather and radio reception, we shall perhaps find in the radio a new link to aid in answering the question often asked: "Is there any relation between sun-spots and the weather?"

Quite apart, however, from any radio observations, H. Helm Clayton has found considerable evidence for changes in barometric pressure over the earth accompanying changes in solar activity. In years of sun-spot maxima he has shown[1] that the atmospheric pressure is lower in the equatorial region covering a belt of about 30° north to 30° south latitude. At this same time of maximum solar activity the pressure is shown to be higher in both hemispheres from about latitude 35° to 65°. There is also some evidence that the tracks of the highest and lowest or the familiar anti-cyclones and cyclones which produce our short period weather changes migrates through a limited range during the 11-year solar cycle. Dr. Abbot at the Smithsonian Institution has been measuring the intensity of the solar radia-

[1] "The Atmosphere and the Sun," by H. Helm Clayton. Smithsonian Miscellaneous Collections, Vol. 82, No. 7, June 9, 1930.

tion for several decades not only at Washington and California but at remote stations in Chile and Africa. With apparatus of great precision he has found that there is in general a falling off in the amount of heat the earth receives from the sun during sun-spot minima as recorded at all stations. A corresponding rise in the amount of heat received from the sun by the earth accompanies the rise to sun-spot maximum. The total range in the value of this solar radiation, or the so-called "solar constant," is of the order of about 3 or 4 per cent.

Perhaps one of the most remarkable and most romantic stories in science relative to sun-spots and seasons of dry and wet weather is to be found in the work of Professor Douglass at the University of Arizona. Dr. Douglass has given a life-time to the study of tree rings. Many of us strolling through the woods have amused ourselves in counting the rings left in the stumps after a recent clearing, thereby determining the age of the tree. Perhaps fewer of us have been aware of the inequalities of the spacing of those same rings. Where the annual rings are widely separated we have the record of years unusually favorable to growth. Where the rings are narrow, we have similar records of years less favorable to growth. From the study of many thousands of trees, Dr. Douglass has been able to show very definitely that years of drought and relatively wet weather in the southwestern part of the United States show a close correspondence with the sun-spot cycle. The Arizona redwoods and the California sequoias appear to have been recording years of maxima and years of minima in the movements of sun-spots even long before the invention of the telescope. To analyze the complex data which he collected, Dr. Douglass devised a special apparatus called a cyclograph, which has proved a great aid in discovering these cycles hidden in tree-ring growth. While the 11-year sun-spot cycle could be traced very definitely through the century, Douglass was much perplexed by the apparent lack of any significant cycles during the latter part of the seventeenth and early part of the eighteenth centuries. In fact, his theory of sun-spots affecting tree growth broke down so exasperatingly during this period that he nearly abandoned the idea of connecting sun-spots with weather cycles. It was in 1922 that Professor Maunder, however, called Professor Douglass's attention to the fact that old astronomical records had turned up, showing a great dearth of sun-spots from 1645 to 1715. This was cheery news, for it is obvious that the trees behaved just as they should have behaved in giving no definite indication of a sun-spot cycle during this interval.

While Professor Douglass interprets the spacing of his tree rings in terms of periods of drought and wet weather, it seems not unreasonable to suppose that there may be other factors besides precipitation which enter into the favorable growth of trees. Perhaps the amount of sunshine, variations in its quality and the proportional amount of heat and ultra-violet light in the sun's beams are other factors favoring growth. The tree, therefore, may be looked upon as a biological specimen which has integrated all the favorable factors to growth which pass through cycles corresponding to cycles in solar activity.

If trees, then, may be regarded as scientific recorders of changes in the sun, one may well ask, "Are there other biological specimens which may in one way or another be expected to respond to changes in the solar cycle?" We have now to mention again the data that have been collected from the records of pelts of fur-bearing animals. That the number of rabbit pelts reported appears to vary inversely with the sun-spot curve may or may not show a causal relationship between the productivity of the rabbit and solar activity. One might, of

course, have to suppose that the energy with which the trappers pursued their vocation had its effect upon the rabbit curve. Nevertheless, joking aside, the periodicities long observed in fur-bearing animals offer food for thought. One of the most puzzling difficulties in dealing with these even conspicuous cycles is the slow change in phase which one often encounters or what one might call a lag or lead of one curve with respect to the other which may accumulate through the years.

There are other noticeable cycles in the affairs of the earth, such as those noted in the outbreak of epidemics, as in the case of poliomyelitis and diphtheria. The latter disease has a well-known seven-year period. The fact that this appears to show no relation to the solar cycle of 11 years may or may not have anything to do with the argument. The Ptolemaic astronomer who in the epoch of the geocentric theory observed that the opposition of Mars occurred every 2.14 years would scarcely have thought that such a curious period had anything to do with the earth revolving about the sun in exactly one year. From the point of view of modern planetary theory, we know that it is the combined motion of the earth around the sun once a year and the similar journey of Mars about the sun once in 1.88 years that is responsible for the synodic period of Mars of 2.14 years' duration. If, therefore, some organism producing human epidemics has a life cycle different from that of its host, one or the other of these factors might vary with the 11-year solar cycle and yet give a combined result of an approximate 7-year period. This in itself is, of course, no argument for the solar effect upon disease outbreaks, but merely calls attention to the fact that a lack of correspondence in the duration of such cycles with the solar cycle is no ground for rejecting such connections.

It is interesting to speculate on the possible ways in which the variation of solar activity may affect the sun's radiation, which in turn directly or indirectly has its effect upon vegetation and possibly ultimately even man's behavior. At the Smithsonian Institution in Washington, at the Mayo Foundation in Rochester, Minnesota, and at the Boyce Thompson Institute for Plant Research at Yonkers, New York, many interesting experiments have been made and are being made that have shown how the behavior of growing plants responds to the particular wave-lengths of light that are utilized in the experiments. The exposure of lettuce seeds to sunlight prior to planting appears to be very necessary to their germination. Apples may be artificially ripened by an extra dosage of ultra-violet light, giving that lustrous redness to the skin so desirable for the fruit vender. Young tomato plants, on the other hand, wither and die under exposure to the ultra-violet light from the mercury-quartz lamp.

The effect of ultra-violet light as a prevention of rickets in animals is well known. Is it possible that we shall yet find that there is a relation between the quality of sunshine and the anti-rachitic vitamin D produced in plants? It has been found that the tissues of plants which ordinarily have little or no rachitic value are rendered more potent by irradiation from some source of ultra-violet light. An extra dosage of this ultra-violet radiation, if not exceeding two minutes, is followed by an increase in the amount of ash, calcium and phosphorus in the leaves of certain plants. Not all plants, however, respond in the same way. Cabbage, a vegetable completely lacking in anti-rachitic properties, has shown no response to such ultra-violet treatment. On the other hand, alfalfa grown in Arizona and cured in bright sunshine possesses a potency that is not found in the same plant cured in darkness. It would appear that vitamin D or the all-essential ergosterol is increased by exposure to ultra-violet radia-

tion. Ultra-violet light from the sun, however, is not an unmitigated blessing and an over-dosage of sunshine may be injurious to certain sensitive plants.

Is it possible that changes in the amount of ultra-violet and sunshine, which have definitely been measured and found to vary with the sun-spot activity, may be responsible for slight changes in the character of the crops? May it be that we shall sometime discover vintages in food as well as in wines due to changes in nature which are, as yet, not under our control? While, as we have mentioned, ultra-violet light is stimulating to seeds, it is the green part of the solar spectrum which appears necessary to the normal growth of the seedling and the manufacture of the chlorophyll so characteristic of green plants. It appears to be the visible region of the solar spectrum and the near but not extreme ultra-violet that enter into the process of photosynthesis. Just what effect small variations in the quality of sunshine may have upon the production of all the various vitamins that are essential to health and happiness we do not know.

Medical science is beginning to find a connection, however, between the vitamins we eat and our physiological behavior. It would not be surprising to find through further investigation that the sensitive ductless glands upon which our temperaments and moods appear to depend are affected by the vitamins in the foods we eat and the degree or quality of the penetrating radiation to which we are subjected. Perhaps some day we shall find that the psychology of the human race passes through periods of optimism and depression in some subtle way that depends upon changes in our terrestrial environment for which changes in the sun may be the ultimate origin.

If such is the case, then the rather fantastic idea that sun-spots may have something to do with economic cycles, as was so seriously proposed some years ago by Jevon, may have some foundation. When one examines curves of business activity such as those compiled from Dow-Jones averages or those of Colonel Ayres, of the Cleveland Trust Company, one is indeed startled by the similarity of the variations in the world economic situation and the activity that has been taking place on the sun during the last decade. The fact that the last sun-spot maximum coincided with the peak of prosperity in 1928 and 1929 and the last minimum occurred at the bottom of the depression in 1932 and 1933 may be a mere coincidence. When, however, one examines data further back in history, it is interesting to note that 5 of the 7 greater depressions have followed in the wake of maximum disturbances on the sun. The sun-spot maximum in 1884 was followed by the depression of 1885. The next maximum in the solar cycle was reflected in the depression of 1893 and 1896. When the sun-spots topped their market again in 1906, it was but a little more than a year before the panic of 1907. Four and one-half years after the sun-spot maximum of 1917 came the depression of 1921 and 1922. The depression of 1903 and the pre-war depression of 1914, however, find no counterpart in the solar curve. Of course, certain circumstances in world affairs may have complicated the economic curve a bit and delayed or accelerated here and there certain terrestrial events over the sun's wishes in regard to the matter.

Seriously, however, human psychology and results of human behavior do respond to environment and probably to the condition of the atmosphere we breathe. We have all noticed how on some bright sunshiny days we feel ambitious, energetic and glad to be alive, while during prolonged, dreary rains we often become discouraged and inefficient in spite of our best efforts. Perhaps the weather was to blame and perhaps the character of the air had something to do with it. Every day the electrical condi-

tion of the atmosphere is being measured at the Department of Terrestrial Magnetism at the Carnegie Institution in Washington. It has been discovered that the number of large ions increases after sunset, whereas the number of small ions increases during the early morning hours. Perhaps here is a difference in the quality of day and night air of greater importance than humidity. Recent experiments at the University of Frankfort by Professor Dessauer have indicated that patients exposed to air containing a large number of the positively electrified ions develop a feeling of fatigue, dizziness and headache. As the positive ions were slowly removed and new negative ions created within the air-conditioned room, fatigue and headache gave way to exhilaration. The inhalation of negative ions at frequent intervals over periods of several weeks has been found to generally improve conditions of high blood pressure in 80 per cent. of the cases. Whether the character of the ions in the lower atmosphere is materially affected by changes in solar radiation with the sun-spot cycle, we have as yet insufficient evidence to determine. The question of the electrical potential drop from the atmosphere to the ground is a subject of only relatively recent investigation. Meanwhile, researches in medical circles and biological laboratories give increasing evidence as to the electronic character of all our physiological processes.

Such speculations as those in which we have just indulged are, at present, without much scientific foundation but offer sufficient food for thought as to nourish a wholesome state of openmindedness without which scientific progress in new and untrodden fields can not be made.

Differentiating then between such facts as have been definitely established by observation from such interesting topics as those which intrigue our imagination, we may summarize briefly the present state of our knowledge as to the effect of the sun on human affairs.

(1) We definitely know of the existence of sun-spots as terrific cyclonic storms in the solar atmosphere generating powerful electromagnetic fields.

(2) Sun-spots come and go in definite cycles of approximately eleven years' duration, a fact which has been established from at least three hundred years' observations.

(3) Magnetic changes in the earth are definitely known to accompany the rise and fall of sun-spots. This fact rests upon careful observations of variations of the compass and measurements of the strength of the earth's magnetic field for over a century.

(4) Auroral displays are known by actual observation to be more numerous and more brilliant at times of sun-spot maxima. That the auroral displays are due to electric discharges in the high atmosphere produced by electrified particles emitted from the sun appears to be the most workable hypothesis to account for auroral phenomena.

(5) The close correspondence between the character of radio transmission and the sun-spot numbers appears to lie beyond any reasonable doubt as a result of quantitative measurements made during the last fifteen years.

(6) The theory of propagation of radio waves presupposes the existence of an ionized region of the earth's atmosphere, the ionization of which is chiefly produced by the ultra-violet light of the sun, which may be seriously modified by the bombardment of electrified particles emanating from the sun during the occurrence of sun-spots. The fact that the behavior of radio reception responds more closely to the occurrence of spots in the central zone of the sun and, therefore, near the sun-earth line is a strong argument for a theory of corpuscular emission from the sun-spots themselves.

(7) Changes in both the amount and

quality of solar radiation with the sun-spot cycle have been definitely established by quantitative measurements of the Smithsonian Institution and of the Mount Wilson Observatory of the Carnegie Institution. The Smithsonian Institution has found a 3 or 4 per cent. variation in the total quantity of radiation emitted from the sun; and the Mount Wilson Observatory has shown that the proportional amount of ultra-violet light varies from day to day and year to year, the ultra-violet light in general being strongest near a sun-spot maximum.

(8) The effect of sun-spots on biological behavior appears to have been established beyond contention through the growth of trees whose ring patterns have been definitely shown by Douglass to show the sun-spot cycle through the centuries.

(9) The possibilities that the changing quality of solar radiation may affect directly the growth and character of the foodstuffs we eat and the consequent behavior of ductless glands is a problem for future investigation.

(10) The fact that one's physiological and psychological behavior depends upon the movements and charges of the ions or electrified particles in the air we breathe results from definite experiments already performed. The possibility that the movements and character of these ions of the lower atmosphere change with the sun-spot cycle is at present speculative but is open for investigation.

(11) The question of the effect of the solar cycle on the weather is highly complex, but sufficient evidence seems to have been presented to give a basis for believing that storminess on the earth migrates through definite cycles, which follow in general the cycle of solar activity.

(12) The dependence of economic conditions upon weather, on the physiological and psychological behavior of man, appears to be a reasonable assumption. The connection between this assumption and changing solar conditions is at present highly speculative, but may be taken sufficiently seriously as to open up definite fields of investigation.

Such of the above facts as have a definite scientific basis are sufficiently numerous to lead us to believe that the sun may have more far-reaching effects upon terrestrial affairs than we have been accustomed to suppose. Speculations are always entertaining, but if real progress is to be made, one can not overemphasize caution against drawing conclusions which scientific evidence is not sufficient to justify. On the other hand, unwarranted dogmatism as to the nonexistence of some of the relationships between the sun and the earth upon which we have speculated is inconsistent with the spirit of openmindedness which looks toward the scientific conquest of the unknown.

IN QUEST OF GORILLAS

IX. CONGO QUEER 'UNS

By Dr. WILLIAM KING GREGORY

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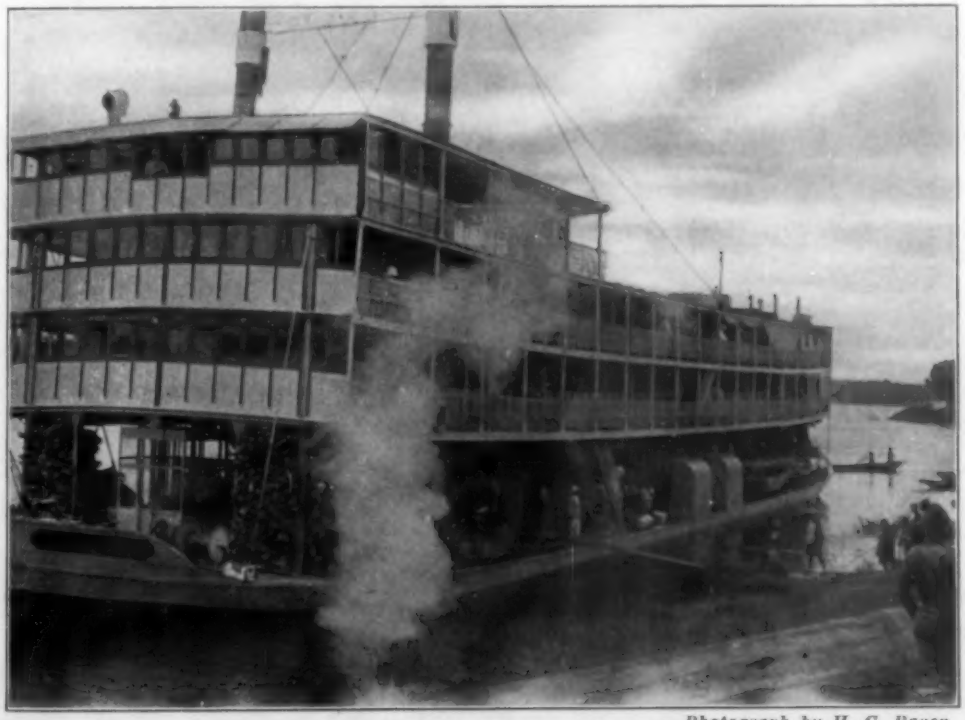
EARLY in the morning of October nineteenth we bade good-bye to Engle, while Raven, McGregor and I embarked on the big river steamboat *Kigoma* for a nine or ten days' trip down the Congo. This boat was a stern-wheeler made in Pittsburgh, Pennsylvania, after the pattern of the big boats on the Ohio River, but the superstructure had been built by the Belgians. It was very shallow and broad and could come so close to the bank of the river that only one or sometimes two long planks were necessary for a gangplank. As on the Lualaba River, landing was effected after two powerful blacks had plunged into the river with steel cables, one at the bow and one at the stern, and after swimming to the bank had passed the cables around some stout trees.

The river below Stanleyville widened out and was dotted with islands. Tributaries flowed into it at frequent intervals. The jungle seemed to differ from that on the Upper Congo (Lualaba) in the abundance of rattans, which are semi-parasitic palms that have become like vines, with long leaf-tendrils that cling to the other trees. Much of the jungle looked as if it were subject to occasional

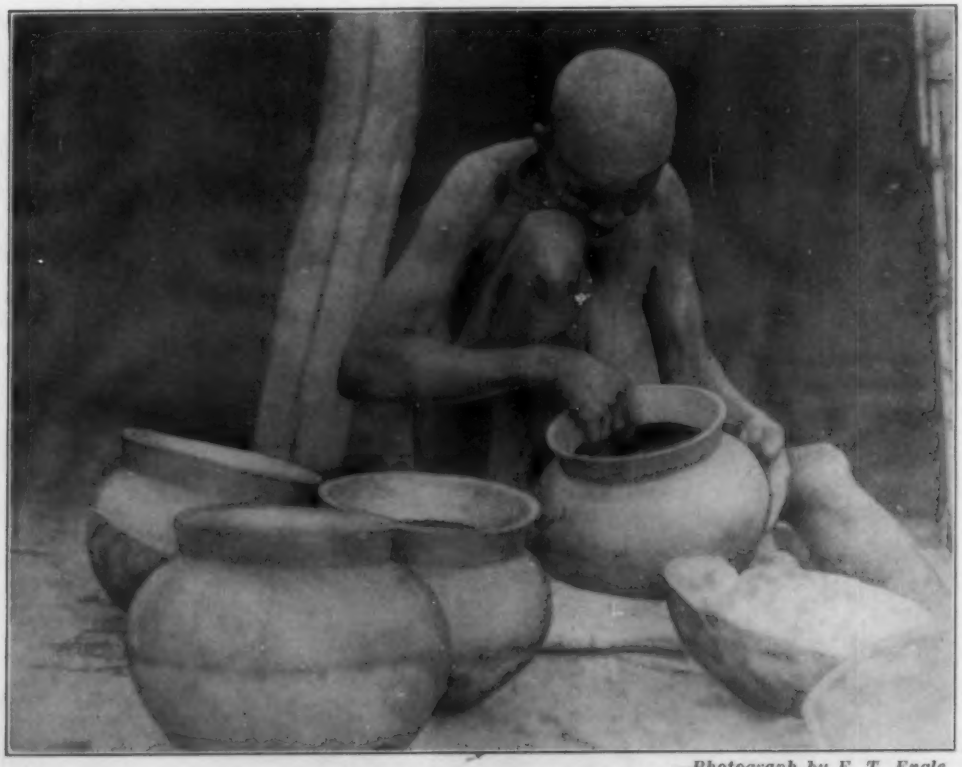


—Photograph by H. C. Raven.

A "MISSISSIPPI STEAMBOAT" ON THE CONGO.

—*Photograph by E. T. Engle.*

AT THE EDGE OF THE JUNGLE.



—*Photograph by E. T. Engle.*

TURNING POTS BY HAND.

flooding. With our field glasses we could watch the many kinds of birds in this forest, but hippopotami and even crocodiles were seldom seen by any of us. Every few hours we stopped at a village to take on wood and late in the afternoon we would tie up at some town or village for the night.

At the wood stations the people were fairly primitive, living in oil-palm houses. Here we could see an amusing *mélange* of nearly naked savages and a few sophisticated and superior persons with at least parts of white men's clothing. At one village, strung along a high bank for perhaps a third of a mile, a native chief, riding a nickel-plated bicycle and attired in white duck suit and sun helmet, rode parallel to the steamboat the length of the village, bowing grandly to the admiring blacks that swarmed on our main deck. There were also large towns with many *magasins* or trading shops, where the native products were bought and European-made merchandise sold by great companies that have stations all over the Belgian Congo.

At Basoka (October 20) a town where "all the world" was gathered to see the steamboat come in, I had the opportunity of observing a characteristic incident of the native folk ways. One family of nearly naked savages had come up in a canoe to buy or sell or merely look on. They had drawn up the canoe on the bank and had left in it a very tiny naked boy to mind his baby brother. It was amusing to see how faithfully he held the baby on his lap and acted as nurse to the rather fitful infant. When the whistle blew the baby began to bawl, but his gentle efforts to quiet it were soon successful.

Among the crowd on the bank at another town, a boy of perhaps nine was making a determined and insistent attack upon a somewhat larger boy, punching him in the face and body. One man tried to stop the aggressor, who broke away and pursued his retiring opponent.

—Photograph by J. H. McGregor.
A NEGRO ALBINO.

—Photograph by E. T. Engle.
TEMPORARY EMBELLISHMENTS.

Then another man tried to stop him, and then a woman, with as little result, the attack and retreat lasting until the combatants disappeared in the crowd. None of the adults seemed angry and they did not jabber as much as they would ordinarily. A fellow passenger who knew well the ways of the natives told me that very likely the persons who tried to stop the boy were relatives who did not wish to be disgraced by his unseemly behavior, or who possibly knew more of the merits of the quarrel than we did. But, my informant said, if the boy is really a persistent trouble-maker, severe measures will be taken with him. First, his uncle and several other men may force him to run a gauntlet, inflicting a severe beating upon him. If after this punishment he later becomes known as an incorrigible, he will have red pepper rubbed into his eyes. So here for a moment the veil was lifted upon the lurking ferocity of the ordinarily genial and long-suffering natives, who in many parts of Africa inflict a most terrible form of mutilation upon girls at puberty, in the name of old custom and religion.

—Photograph by H. C. Raven.
PERMANENT EMBELLISHMENTS.

At one town we had the pleasure of seeing a baby chimpanzee playing on the front lawn of a pleasant villa, who did not hesitate to make friends with the strangers. His very lively, almost aggressively friendly disposition was characteristic of his race and in wide contrast to the lethargic movements and reserve toward strangers of many young gorillas.

Among the crowds of interested black spectators was a Negro albino, a most unholy-looking individual with pale and yellowish-pink freckled skin, unpigmented iris, squinting eyes and light hair. He was one of several which we saw in the Belgian Congo. Beautiful brown skins of slightly reddish tinge seemed to us far more abundant than in the Kivu region, and we did not know whether this was due to the infiltration of white blood, which on the Lower Congo River must date back several centuries, or was merely an expression of the astonishing variability of the Negro race, as it was often coexistent with purely negroid nose, lips and hair.

As Lisala (October 22) we saw a large blue butterfly with very long wings and bird-like flight. Here we climbed a very high bank, including long flights of steps, to what was at one time the level of the river, and from the top we could look over to the far-distant bank of the other side, with many an island and channel in the present flood-plain. In a long walk through the native town we saw several little girls making garlands for each other; they looked especially charming. Then we saw and photo-

—*Photograph by J. H. McGregor.*

A WOOD VILLAGE.

graphed an old woman, bending under a heavy load. She was adorned with elaborate patterns of wart-like cicatrices, arranged in neat rows and curves on her forehead, nose, cheeks, breast and abdomen. Strange to say, the general effect was rather decorative. Two young girls with similar adornments were next glad to pose for their photographs. Then we went on down a long mountain path to a stream where native women were treading and squeezing out the oil from the nuts of the oil palm.

At one village where we stopped to take on wood (October 24) I was galvanized by the sight of a large living *Protopterus* in a wooden bowl in front of a native house. This thrice-venerable lung-fish is the lineal descendant of the fossil lung-fishes of the Devonian period, rocks from this period being provisionally estimated to be about three hundred million years old by the "radium method" of the physicists. Its great geologic age had not mellowed its disposition, however, as it bit viciously at an admiring finger. The woman that owned it, too, crabbedly refused to be tempted by francs and curtly dumped it into the pot. Almost immediately afterward my temperature went up another degree or two at the sight of a dead *Polypterus*, like the one already eulogized in these pages. After returning to the steamer I found one of the *parvenus*, or recent intruders among these ancients, in the form of a good-sized carp of the genus *Barbus*, representing a prevailingly northern family, which according to the best evidence at our disposal could not boast of more than a million or two years of residence south of the African Mason and Dixon line.

Another relic of vastly more ancient

times was a six-inch centipede, which insisted on crawling up Mr. Raven's leg while he was taking a shower bath in a dark cabinet. Perhaps the cold water made the beast sluggish, for it did not attempt to bite. Raven calmly brushed it off and then called the deck steward to come and remove the wooden grating under which it was hiding. The darkey very gingerly dragged it out with a stick and it was lost to science by being thrown overboard.

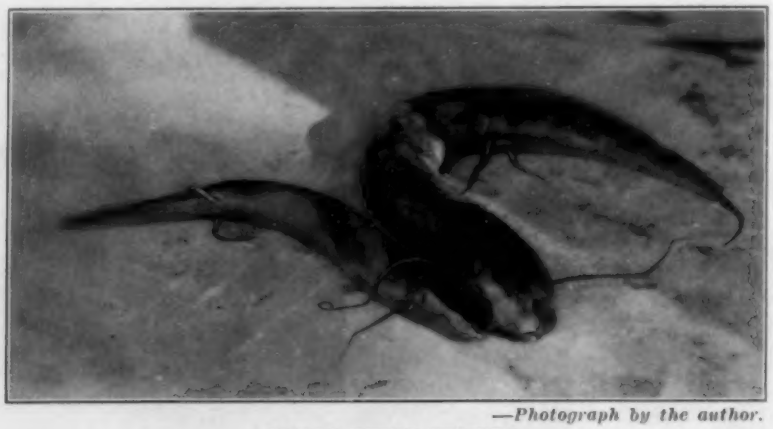
We found Coquilhatville (October 25) to be a very progressive and smart-looking modern city with a large native settlement, both of which we viewed on our auto ride to Eala, which is one of the great botanical gardens of the world. For mile after mile we drove through plantations of coffee, cacao, rubber and many other trees, passing at the end through a long tunnel formed by closely over-arching bamboos. The catalogue of this Botanical Garden includes several hundred species of trees, bushes and plants, which can be furnished in quantity as slips, seeds or cuttings to any part of the Belgian Congo. This enables the Belgians to plant thousands of trees along the automobile roads and to raise great crops of wood from such rapidly growing trees as eucalypts, which are planted in groves in formerly devastated areas.

On the very high bank of the river at Lukolela (October 26) there were extensive formations of laterite, a kind of reddish "pudding stone" of quite recent solidification, very abundant in many parts of Africa and covering the older geological formations. Here also, as in so many other regions, many of the oil palms bore abundant nests of the bustling yellow and black weaver-birds, who manage somehow to weave the tough, pouch-like nests and line them with fine material.

As we went on down the river below Coquilhatville (October 27) it first widened out greatly, being almost lake-like, and then gradually narrowed again as it approached the "water-gap" leading to Stanley Pool.

Below Bolobo an insane passenger, a sick man on his way to Belgium, locked his poor wife in the stateroom and then leaped over the rail into the river. A boat was sent out and the *Kigoma* circled around for a long time, but only his floating sun-helmet was retrieved; the body was swept down the swift current and so far as we heard was never recovered.

We were delighted to find that two of our neighbors in nearby cabins on our deck were young geologists, who had been making maps and special studies in certain parts of the Belgian Congo. One



—Photograph by the author.

CONGO LUNG-FISHES.

—*Photograph by J. H. McGregor.*

A PATHWAY AT EALA, BORDERED BY OIL PALMS.

of them, M. Lohest, was the son of the late Professor Lohest, who some years ago entertained Dr. McGregor when the latter was studying the fossilized human crania found in Belgium and France. He and the other young man, M. Staquet, helped me greatly in interpreting the geological features which I had been observing on the way down the river. For we were now (October 28) passing by great cliffs of the "Lubilache" formation, mostly buff-colored sandstones, which had been laid down presumably in fresh water in Triassic times but had been cut through by the present river in quite recent geologic times. Below Black River and above Stanley Pool the river makes a sharp swing toward the southwest as it passes through the mountains. Here at sunset one could gain a view of dark mountain wedges in the foreground and hazy barriers in the distance.

At a village some way up the mountain on the left bank in this region the headman, who wore a massive neckband of incised brass, showed us some huge clay vessels which he said were filled with "goobas"; when he handed us some of these, we recognized the peanuts of our

—*Photograph by E. T. Engle.*

RIVER SCENE NEAR LUKOLELA.

THE PEOPLE HAVE BROUGHT THEIR SICK FOLK TO THE HOSPITAL, LEAVING THEIR CANOES AT THE SHORE NEAR BY.

southern states, where they are frequently called by this name. As the peanut is supposed to have originated in Brazil, it may have been introduced into the Congo Basin by some early slave trader or missionary.

On the morning of October 29 we passed into the great expanse known as Stanley Pool, which is flanked on the north bank by buff-colored cliffs of the Lubilache formation (wrongly regarded as *craie* or chalk by some Belgians). Kinshassa, the end of our ten days on the river boat and the largest city in the Lower Congo, is near the lower end of the pool.

At Leopoldville, which is immediately west of Kinshassa and continuous with it, we were invited by the Reverend Emory Ross to visit the American Baptist Mission. Here I saw a building which dates from Henry M. Stanley's time. Mr. Ross told me that one old Negro, now connected with the mission, had been present as a baby when there was a fight between the natives that were with Stanley and those that were opposing his advance. In this fight Stanley's men killed the men in a certain village and carried off the women, including this man's mother and himself.

While staying at Kinshassa we made two visits across the river to Brazzaville, which is the seat of the governor-general of French Equatorial Africa. Here we saw clearly for the first time representatives of the tall, very black Negroes from West Africa, who are dressed in voluminous white robes. Governor Antonetti received us at his villa with great courtesy and gave us a letter to Governor Marchand of the French Cameroon, where we had decided to go in search of the West African gorilla.

Meanwhile we had given up our plan of going back up the Congo River to the Sanga, as we learned that it would be several weeks before the next boat started

and that it would be a twelve-day trip. We accordingly decided to take the "*Chargeurs Réunis*" line from Matadi up the west coast, and to get off at Douala in the French Cameroon and then go inland.

Brazzaville stands in wide contrast to the bustling Belgian cities to which we had become accustomed. It is a much older, rather sleepy place, sprawled over a wide territory. But an artist could have reaped a harvest of interesting color sketches of the natives. Their highly varicolored garments were often bleached out by the rain into pleasing soft tints, and it seemed to me that even the patterns were more reminiscent of French art and less crude and commercial-looking than those to which we had become accustomed on the Congo River.

Yellow-brown Chinese coolies working on the railroad afforded a strange contrast to the black and reddish-brown people by whom we had so long been surrounded. In Brazzaville there were more tall black men with good beards than in the Kivu region, and everywhere we received suggestions of North and West African influences.

The small ferry boats that run across the broad river between Brazzaville and Kinshassa were run by black engineers and captains; the latter seemed to be efficient in managing the boats in the river currents. On the way home from Brazzaville the sunset as seen behind Stanley Pool was so stupendous as to defy description, but it stands out in my memory as the peer of any I have ever seen, either in the tropical Pacific or in Africa.

One of our fellow guests at the hotel in Kinshassa had a large crate full of young parrots, which he and his wife were taking back to Europe. At night the crate was set on the veranda just out-

—*Sketch from author's notebook.*

SUNSET NEAR BLACK RIVER.

side our windows and the little dears started their all-talking performance at sunrise. As they were not English-speaking parrots I trust they did not remember any of the bad language they might have overheard, if they had stopped to listen.

At Kinshassa we left our two black boys Poussini and Musifiri with all their wages and presents, together with the passage money back to their homes on the other side of Africa. Matambele had stayed with Engle at Stanleyville. Raven rehearsed carefully with them each stage of the journey, which they learned very well as they had good memories and were by no means stupid. But as it proved impossible for us to buy the tickets in advance for third-class passengers, Raven warned them that if they wasted their money and did not buy their own tickets at each stage of the return journey, they would fall into the hands of the police. They promised solemnly to follow this good advice, but Dr. Engle learned later that they were still at Kinshassa. However, in a country where so many young men wander far from home this was nothing unusual and we can only hope that their experiences with us and our letters of recommendation, added to their native talents, stood them in good stead in getting places as cook and general servant, respectively.

From Stanley Pool to Matadi the Congo is unnavigable for large boats, since as it descends from the continental plateau to the coastal plain it abounds in rapids and falls. Hence the vast inland waterway of the Belgian Congo can at present be linked to the seaboard only by means of a railroad which pierces the crystalline mountains that mark the western bulwarks of the continent. Accordingly at Kinshassa we took the train for a long day-and-night ride over the mountains to Matadi on the Lower Congo, the Belgian port for ocean-going vessels. We stopped for supper at Thysville in the mountains, a town named for General Thys, the engineer who forced the railroad through this desolate country at the cost of fearful mortality among the workers. Here the finely plaited rocks of the Lower Congo system are exposed, and it was a great satisfaction to have many new glimpses into the foundations of the continent.

(A further article in the series entitled "In Quest of Gorillas" will be printed next month.)

THE JIBARO, AN AMERICAN CITIZEN

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THE Jíbaro is an American citizen of whom relatively few Americans are aware and in whom they may take little pride. Although an American citizen, he knows not the meaning thereof and may not even be aware of the high honor thrust upon him by official decree. How should he know and why should he be thankful, never having been taught nor affected by the transfer of his allegiance in which he took no part. In his own circumscribed and prescribed thinking he is the same Jíbaro, no matter what the citizenship, no matter what the form of government or by whom it is administered. He doesn't bother about citizenship; it is food that he wants. Life to him goes on in the self-same, humdrum way with no vision beyond that of his ancestors generations and generations ago. He, in a measure, is to Puerto Rico what our "Southern Mountaineer" is to eastern Kentucky. He, like members of other isolated groups, has become lost in the hills, with little contact economically or politically with world movements. In fact, history has ignored him and passed him by, as have also the comforts and conveniences that make the life of the average American so rich and full. All this has left him in his loneliness of thought and action and misery.

The Jíbaro is very definitely a product of his environment. He is a little more. He is not only a part of all that he has met but also a part of Indian, Spanish and Negro cultural elements fused into one. Were it not for the fact that he makes up the bulk of the population of Puerto Rico, he might be passed by as an oddity, a misfit, meriting only a dilettante interest, as in the main has been

AVENIDA PONCE DE LEÓN LEADING PAST THE CAPITOL

THE BEAUTY OF THE ISLAND IS IN SHARP CONTRAST WITH THE MISERY OF THE JÍBARO.

accorded our Southern Mountaineers. There is, however, a distinct difference between the two groups. Although our mountain people have been looked upon as backward, with a colorless existence broken by moonshine and feuds, their plight has aroused some interest and attempts have been made to improve their economic and social outlook. Educational institutions of various grades, active in the region, are monuments to the milk of human kindnesses of a few. The Jíbaro in contrast has not had even this aid. He, in the main, has had no stimulus from the outside and, what is more, has been ruthlessly exploited by those privileged to help him.

The name Jíbaro (Hē-bä-rō) is one given long ago in Puerto Rico to a person living in the country. At present he is an ignorant, superstitious, pathetically poor country peasant on American soil. A century or so ago, the name was spelled Xívaro, but the meaning was the same. In the appellation there is no connotation of disrespect nor does it carry any stigma. It is accepted by these people with equanimity, and they may even name the little roadside stand *El Jíbaro*. Cultural influences on them have been extremely limited. The church, as in so many backward communities, has had little influence, perhaps more than appears on the surface. The Catholic church, always a potent factor in the spiritual life of primitive Latin American people, has done little in advancing their cultural evolution. The Protestant churches, beginning about the time of the American occupation, have done some creditable work, but little or nothing in an important way where most needed. During this American period, the Catholic church has also been much more active, both groups helping the people economically as well as trying to take care of their spiritual welfare. The work done, commendable as far as it has gone, has been in general negligible, ameliorative rather than constructive.

The Jíbaro, however, has been undergoing a genuine metamorphosis during the last few years, and it is doubtful whether he ever again will be satisfied to go back to his former status. A new outlook is being brought to him directly and indirectly through the PRERA, as the Puerto Rico Emergency Relief Administration is known to him. Perhaps no political activity has ever done so much for a people in so short a time. The name Prera will probably live long after the actual P-R-E-R-A is no more.

The training and education received through the various governmental agencies, especially the CCC camps, have been the most vital element that has ever come to the Jíbaro and are bringing to him a new point of view, a new lease on life. The old established order is receding rapidly. Unquestionably, at no time in the past history of the Jíbaro has he been so much of a personality as now. The recognition received has given him a sense of personal values which is new to him and which he can not be expected to relinquish graciously. He is beginning to see visions, and old and young alike appear in the public demonstrations for a place in the reconstruction of all, not part, of Puerto Rico. During the boom days, many migrated to the cities and added their quotas to the slum sections where they have eked out a precarious existence, in many cases in poverty even greater than they had endured in the rural districts. These migrants, also, are united under the same magical name of *Prera*, which to their simple minds promises so much. The word *habilitación* is known to all and is a common one among them. The greatest of all demonstrations known in the capital city was held on Saturday, July 6, 1935. Banners bore: "The women protest against the legislature." "Hunger demoralizes a people." "Legislators, how long will you abuse our patience?" "Down with the large corporations and rich land-owners." "Give us a New

"EL JIBARO"—A ROADSIDE STAND

SELLING BARBECUED ROAST PIG. THE JÍBARO CHILDREN ARE OF THE BETTER TYPE, BUT THE SPINDLY LEGS OF THE BOY INDICATE THE LACK OF PROPER FOOD.

FARMING ON THE MOUNTAIN SLOPES

A TYPICAL SERIES OF HILL SLOPES WITH THEIR CULTIVATED FIELDS UP TO A SIXTY-DEGREE SLOPE WITH NUMEROUS DWELLINGS, A FEW OF THEM SHOWING AS WHITE SPOTS.

IN THE CARIBBEAN NATIONAL FOREST IN NORTHEASTERN PUERTO RICO. TRUNKS OF TREES ARE SHOWN COVERED WITH ORCHIDS, PENDENT LIANAS AND TREE FERNS IN BACKGROUND.

TRUCKS ON A BUSY STREET

A PART OF THE CONGESTED WHOLESALE DISTRICT OF SAN JUAN, WHERE, WITH PONCE AND MAYAGUEZ, THE WEALTH IS CONCENTRATED.

Deal." "President Roosevelt is a more patriotic Puerto Rican than our legislators." And so on.

Physically and culturally as well, the present Jíbaro is a product of four centuries of amalgamation in the New World and his foundations were laid more than a century before the Pilgrims saw the shores of the New World. In 1509 Ponce de León, with twenty men, founded the settlement of Caparra, which later was to become San Juan, the capital city of the island of Puerto Rico. Two years later, in 1511, there were 200 Spanish male adults, but in that year eighty of them lost their lives when the natives rose in open rebellion. In this rebellion a great many natives also met death and probably not more than some 20,000 remained, all of whom in some form or other were distributed among the conquerors according to the *repartimientos* system, an effective way of enslaving a whole people by official decree. Other uprisings among the Indians occurred, but all failed ignominiously and many of the natives left their valley habitat and fled into the more inaccessible mountain areas; some futilely even left for other islands.

Under such a relationship between the two races, it was only natural that the Indian women should soon greatly outnumber the male population, for, as providers, they did not risk their lives in warfare. Furthermore, as the Spaniards were not colonizers, but adventurers, *conquistadores*, many of them members of the nobility who wished only to recoup dwindling fortunes, they did not bring their families with them. As history shows over and over again, the Spaniard in the New World had no scruples in cohabiting, more or less promiscuously, with Indian women, and a transfer of allegiance by the Indian

woman to some white male did not work any particular hardship, as her lot in many cases was greatly improved. Thus the inevitable process of amalgamation was begun early and the beginnings of a Jíbaro class were laid shortly after the discovery of the New World.

In 1528, twenty years after Ponce de León had landed, the excessive numbers of white males in the New World caused the king, in order to increase the Spanish population in the New World, to issue an edict for all Spaniards to marry under pain of forfeiting lands and mandated Indians. History does not say how much effect this edict had, but a census taken three years later by the governor reported 71 Spaniards married to white women, 14 married to Indians and 298 unmarried.[1] Even at this early date, 14 Spaniards had been joined to native women by the rites of the church. The number given as unmarried did not exclude those only consensually married or those who had one or more concubines or lived in a state of free love. The latter groups were the ones with the most numerous offspring. Among the Negro slaves, only three couples were reported as married, the males outnumbering the females three to one. The free but mandated Indians numbered 473, Indian slaves 675 and Negro slaves 1,523. This commingling of the three races and the rapid decrease in the Indian population are most amazing in view of the fact that they were brought about by such a small number of whites in the space of only twenty short years. The Indians, reported in the beginning to be as numerous as bees, twenty years later numbered only 1,148. At this time the Negroes already outnumbered the Indians by a fourth and those who brought about this change, the whites, were outnumbered by the other two, ten to one.

This was the set-up for a Puerto Rican

[1] Brau, "Historia de Puerto Rico," pp. 70–71.

THE MARKET BUILDING AT RIO PIEDRAS

TRANSPORTATION BY BUS IS EXTRAORDINARILY CHEAP. THE JÍBARO MAY BE ABLE TO AFFORD TRANSPORTATION OF HIS PIG ON THE BACK OF SUCH A CARRIER.

race with Negro blood dominating in the coastal regions and tributary lowlands. Indian blood was most plentiful in the interior highlands and the white blood acted as an adulterant throughout the whole. It is the combination of the black, yellow and white elements in their undeterminable degrees of admixture that makes up the present complex of the Jíbaros. To this agglomeration has been added later some Indian blood, somewhat more Negro blood and, throughout a much longer period, a much greater amount of white blood. In this miscegenation, the end product thus far has been what our census of recent decades lists as "Whites," who, however, most commonly resemble the East Indian in color. Seemingly, the soft black hair, curly more than kinky, has been one of the most persistent characteristics of the Negro. This soft, even kinky hair in one of the blond type with blue eyes is not an unusual sight among the hill peoples. The combinations of all types are truly limitless. Indian characteristics as such, except for the straight black hair and almond eyes, are rarely seen, although the scraggly beard and more rarely the high cheek bones are also somewhat in evidence. The people as a whole have surprisingly long and narrow heads. In the main, however, the cultural elements which have come down through the generations are more in evidence than physical features.

Because the Negro element is much more evident in the coastal cities than in the interior, many have been led to believe that Negro blood is much more common than it really is. Slavery in the interior never proved profitable; in fact, it was never very profitable in the coastal region, except where sugar cane was the dominant crop. The country person, therefore, the Jíbaro, is freer

A SMALL SECTION OF A RECENT PARADE

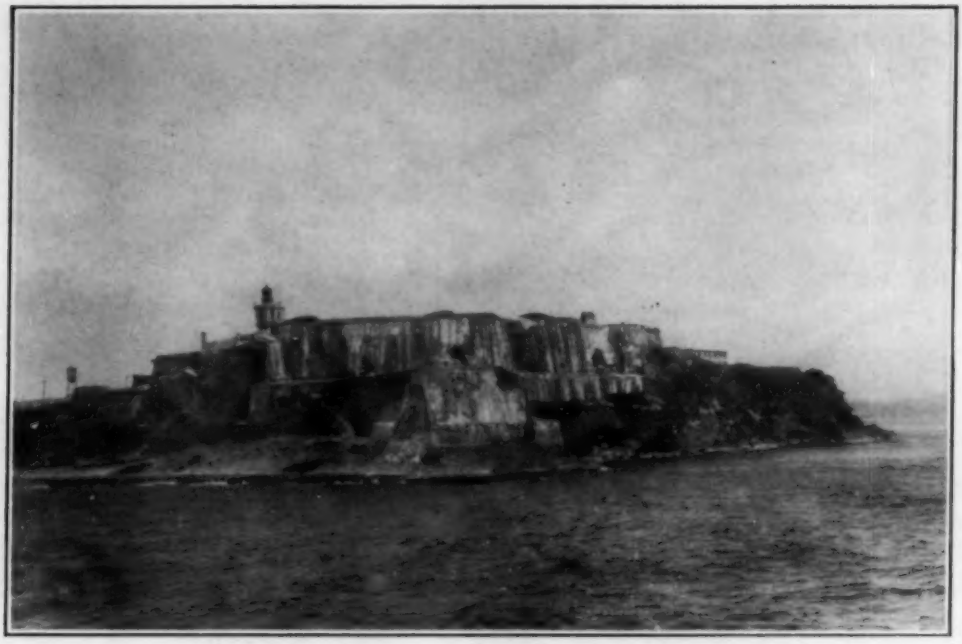
REPRESENTING EVERY MUNICIPALITY (COUNTY) ON THE ISLAND TRYING TO IMPRESS UPON LEGISLATORS THE NEED OF AGRARIAN LEGISLATION TO HELP THE POOR JÍBARO. THE LARGER BANNER READS, "TO HELL WITH THE BIG LANDED ESTATES. RETURN THEIR LANDS TO NATIVE FARMERS."

THE JIBARO IS THE PRODUCER OF DOMESTIC FOODS

Upper left: RED SWEET POTATOES AT THE MARKET, RIO PIEDRAS. *Right:* THE JIBARO BRINGS HIS PINEAPPLES TO THE HOTEL IN PONCE. *Lower left:* BAGS OF CHARCOAL; THE TRANSPORTATION OF GOODS IS LARGELY BY HUMAN ENERGY.

from Negro blood than his city cousin. Since for centuries all parts of Puerto Rico have been occupied practically to their capacity for furnishing a living, there has been little inducement for migration from place to place. Distinct racial characteristics, therefore, are noticeable in passing from one region to another. So established are these distinctions that in certain sections the marriage of cousins and near of kin is looked upon very favorably by parents, with the result that only two or three surnames may be found in such a closely built-up unit area. The pure white Spanish type is almost never found in the interior, although by far the larger number of the nearly *sangre pura* type is found in the interior. Light hair, a fair skin and blue eyes are not at all uncommon, perhaps the result of a later addition of Nordic blood.

The Indian population disappeared rapidly, in spite of the importation of Indian slaves from the neighboring islands and from even far-off Mexico. Whatever their number at the beginning, in less than half a century later no pure Indians remained, except women married to or living with the white man consensually. Since the island served as a Spanish outpost from which expeditions went out, naturally many diseases were imported into the island with a virulence, due to a lack of developed immunity, that swept the natives away as in terrific plagues. Nevertheless, the dominant cause, it seems, of their disappearance was the harsh treatment received at the hands of the white invaders. What seemed at first a fairly humane system of apportioning the natives to some sponsor or overlord soon developed into one of the most pernicious systems the ingenuity of man has ever devised for the exploitation of a weaker people, at its worst probably in the South American plateau countries. Under it the



IN THE SHADOW OF THE FORTRESS WALLS

THE JÍBARO FINDS VACANT LAND ON THE STEEP SLOPES OUT OF REACH OF THE SEA. THE EXTENSIVE SETTLEMENT MAY BE NOTED ON THE RIGHT.

native became an easy prey, in his helplessness, to exorbitant taxes and tributes. The first tribute on record was imposed by Columbus as early as 1495 on the natives of present Hispaniola to the extent of gold the size of a bell on a mule and an arroba (25 pounds) of cotton, every three months for every Indian over sixteen years of age. Later tributes were much more exacting and not uncommonly incapable of fulfilment. Similar tributes were exacted from the natives of Puerto Rico. Only those who were able to escape the clutches of their enslavers left the island in order to avoid payments.

The Negro, by nature, was better fitted for slavery than the Indian. This may be only seemingly so, as the immensity of the West Indian slave traffic is rarely fully appreciated. That slaves should have been imported into Puerto Rico as early as 1510 is only natural, for the home country also had its slaves. As the mines were worked out by 1536 and sugar cane was slow in developing on the island, the slave trade never was as large there as in some of the other islands. In 1860, when the last census preceding the freeing of the slaves (1872) was taken, the total population of the island was given as 583,000. The whites numbered 300,400, the free colored 241,000, and the colored slaves 42,000.[2] This census shows the white and Negro populations about equal.

The racial statistics under the United States census are only approximations to the truth in the matter of color. Negro blood is widely disseminated even among those classed as white. During the early days, the proportion of Negro blood increased very rapidly as a result of Negro importations, but by the end of the first century Negro importation practically ceased and white immigration was given

[2] Abbad y Lasierra, "Historia de Puerto Rico," pp. 302–303.

A JIBARO CABIN ON THE ROADSIDE

MAKING ROOM FOR THE GROWING OF A FEW YUCCAS. THE LEAN-TO WITH ITS DILAPIDATED AND CHIMNEYLESS ROOF IS THE KITCHEN WITH ITS OPEN PLACE FOR FIRE FROM CHARCOAL, GRASS, TWIGS OR DUNG. THE BLUR IS CAUSED BY SMOKE. NEARLY ALL FOOD PREPARED TASTES OF SMOKE.

its chance to gain the ascendency again. Because at present there is a general lack of discrimination in color among the lower classes in their marital relationships, a greater dilution but wider distribution of color is now most rapidly going on. The percentage of colored blood in the enumerations has been rapidly downward, from 87.9 per cent. in 1530, 49.9 per cent. in 1830, to 38.2 per cent. in 1900 and 25.7 per cent. in 1930. The downward trend may be expected to continue until observable negroid characteristics will disappear entirely.

In the present admixtures, white blood greatly dominates and is likely to continue increasingly to do so. Ponce, with his twenty men, soon had many additions. A year after his landing, the number had already risen to 200 male adults. By 1531 there were 869 Spanish males—women and children were not counted. Through the four centuries of Spanish occupation, the white male came and went, but more remained than left. Many of these whites were from the ranks of the nobility, most of them poor because of the primogeniture laws enforced in Spain, but they hoped to amass a fortune in the New World and then to be able to take their established places in high society in comfort. Others, as might be expected, came from other classes, former soldiers, ex-sailors, some misfits of society, and others. The royal decree of 1815 relaxing so many restrictions and offering so many new inducements commercially, brought many pure bloods with their wealth and ability from South American countries, in the throes of revolutionary unrest at that time. Within one week the arrival of 324 Catholics is recorded and also 83 "gentlemen" from Louisiana. The exodus from Venezuela was so great that during the month following the battle of Cara-

bobo in 1821 there landed in Puerto Rico "*Ocho buques y una fragata inglesa*" all filled with "*expatriados.*"[3] Many of the more prominent families of to-day are proud in tracing their ancestry to these groups of pure whites which brought not only fresh blood of high quality but business sense and acumen.

HARVESTING SUGAR CANE

THE JÍBARO AS A WORKMAN IS INEFFICIENT. WORK WHEN AVAILABLE IS FOR LONG HOURS AND THE WORKMAN IS FREQUENTLY FORCED TO REST IN THE SHADE OF THE CANE WITH THE STATEMENT OF *enfermo.*

Here, if anywhere, is the beginning of a marked differentiation into classes: on the one hand, a high-grade cultured group in the minority but controlling the destinies of the island; on the other, the peasant group, the Jíbaro and the urban poor. His competition as a free man with slave laborers gave the Jíbaro a distinctly inferior status. He had to work, in the main, on the same basis, yet without the advantages accruing to slaves. Naturally the wages were what the rich landowner wished to pay. Since a man's existence in the tropics can be maintained on almost nothing, the landowner found it difficult to get the extra supply of labor when wanted for the wages he was willing to pay. As he was the one who made the laws, it was a simple matter to pass one that forced every freed man who did not have enough land to support a family to carry a *libreta* or certificate giving his status. If not employed, he could be arrested as a vagrant. Seemingly, this had little effect on increasing the labor supply, but it did give a distinct advantage to the employer in using the law as a threat to force the Jíbaro to work. The resultant effect, however, was to make the poor still poorer, as wages pitifully low became lower still. Well-meaning as the law might have been in the beginning, it nevertheless gave the Jíbaro a distinctly inferior status, definitely consigning him to a state of peonage, a state which he has held so long that now when in the presence of his superiors he may stand, barefooted, hat in hand, head and eyes lowered as if awaiting the order of an executioner. Such is life for one group of American citizens. This Jíbaro is, therefore, a product not only of his physical environment but also of a system which leads to class opportunities for some and to oblivion for others.

Were this Jíbaro class not so numerous, the situation would not be so appalling. At the time of the *Cédula de Gracias* in 1815, the Jíbaro population was given as 86 per cent. of the total. By 1900, the rural population, and relatively few of its number are not in the

[3] Blanco, "Prontuario Historico de Puerto Rico," p. 63.

TWO MEN AND EIGHT OXEN OPERATE A HARROW

EVEN ON THE LARGER ESTATES THE CHEAPNESS OF HUMAN LABOR IS REFLECTED IN THE PRIMITIVE EQUIPMENT.

Jíbaro class, was 85.4 per cent.; in 1910, 79.9 per cent.; in 1920, 78.2 per cent.; and in 1930, 72.3 per cent. of the total population. This seeming decrease is not due to the rising of some above their class but to a migration to the cities with their increased industrial development of recent years. Many are forced to go to the cities, as no place for them to live is available in their home districts. In the city they build their huts on non-active land, such as on the city front, outside of the old Spanish wall or upon tidal flats. Housing conditions here are unspeakably bad.

Naturally, class distinctions between those who have and those who have not are very marked. Members of the upper class do not take kindly even to the simplest physical tasks. Their superior background, education and even moderate wealth emphasize the distinction and give them a sense of superiority, not assumed, over those who through genera-

ONE OF THE POOREST TYPES OF DWELLING

BUILT OUT IN THE SWAMP NEAR RIO PIEDRAS. THIS PARTICULAR DWELLING HAS ONE ROOM AND HOUSES TWO FAMILIES, A TOTAL OF 15 PERSONS. SUCH A SITUATION IS BY NO MEANS THE EXCEPTION.

AN IRRIGATED CANE FIELD ON A LARGE ESTATE

BEING GRAZED DOWN AS PART OF THE RESTRICTIONS PLACED ON CANE ACREAGE. THE SUGAR CENTRAL MAY BE SEEN IN THE BACKGROUND.

tions of need have developed a subservience hard to understand by an American. Fortunately, now there is developing a strong, energetic middle class which, largely by sheer effort and native ability under great handicaps, is forging ahead. With opportunities this group will take a major part in the evolution of the island. The bulk of the people, fully three fourths of them, however, are in the lower class—urban poor and Jíbaros. Their major distinction is landless poverty, some still poorer than others, until hunger, nakedness, wretchedness and hopelessness are their inevitable lot.

The wretchedness of this group beggars description. It is difficult to escape the ever-present spectacle of poverty in going about the island. The island districts "seethe with misery." Housing facilities, no matter how makeshift, are wholly inadequate. Many are the cases where two or more families with their numerous brood occupy a small, one-room cabin. There is no place for them to build on nor anything to build with. Thus they breathe and breed in a mere animal-like existence outside the pale of the economic life of the island. There is, however, little of that *verdammte bedürfnislosigkeit* sometimes attributed to tropical peoples by those who do not know the tropics. The people are peaceable and kindly, ready to share their meager store with the stranger or run an errand for him, and for the most part are not resentful of those who so mercilessly exploit them.

That the Jíbaro as a workman is inefficient is only too true. It is almost inconceivable to one accustomed to good food and regular meals that the Jíbaro and members of his family have any energy left for work, on the diet conditions forced upon them. With only a cup or two of black coffee for breakfast,

the worker may find it necessary to walk from his hillside cabin several miles to his work, when there is any to be had, and then work from dawn to dusk for less than a dollar a day. At noon he eats his lunch of rice or beans or corn meal in the field and at night, after working hours under a hot tropical sun, he trudges home for his evening meal, rarely with meat, and limited in quantity; then not even to enjoy the luxury of a chair or bed, but to go to sleep in a hammock, or upon the floor without undressing, only to wake up for a repetition of the previous day's experience. This only for a season and then idleness with scarcely enough for a life-sustaining ration. Such is not an isolated case but the common lot of the Jíbaro. He is definitely "a man with the hoe"; the hopelessness of his situation has become almost second nature to him.

The Stars and Stripes has brought no liberty to him that he did not have under the Red and Gold of Spain; it has, in part at least, even intensified his misery. Sugar cane under the protective arms of a tariff law is by far the most profitable crop and, by and large, the only profitable export crop. Sugar lands under the control of large sugar corporations have taken the limited areas of rich, flat coastal lands and have pushed into and up valleys and over low hills and with this extension have gone the food crop lands. Where corn once grew, now cane waves its glossy leaves. The little plot once allotted to the Jíbaro for his crops is now "too valuable for an inefficient Jíbaro to putter around in." With the high density of population of 482 per square mile, no longer does the one acre in ten in food crops out of the total of 2,137,200 acres begin to supply the island's million and a half people with food. Food must be imported, and imported food is too high for the Jíbaro to buy.

FIELDS OF SUGAR CANE

THE PROFITABLENESS OF CANE COMPARED TO OTHER CROPS BRINGS ABOUT A MIGRATION OF CANE INLAND OVER THE BORDER HILLS, CROWDING CORN, THE TRUE FOOD CROP, FARTHER UP THE HILLSIDE.

The plight of the Jíbaro must be alleviated before the island can be said to be on a firm footing. His number is far too large to be disregarded. No nation can advance with such a handicap, no nation can profit with its best lands exploited by foreign corporations, no matter how profitable their industry may be. The resources of the island are too limited to take care of such an over-dense population. The only hope lies in a directed policy that is free of party politics or favoritism. The shame of the situation in which we, the richest nation on earth, find ourselves must be remedied. The American people as a whole condemn whole-heartedly *"Imperialismo Industrial Norteamericano"* when it sucks the life blood of a people.

What is the solution? The more thorough the study, the more complicated the problems become. To the local politician the solution is simple enough. It is independence or at least autonomy. Even a text used in the university at Rio Piedras concludes with:

> The economic interests of New York pauperize us. The dilemma is therefore whether to take into our hands with serenity and firmness our destiny or on the other hand as mental degenerates in long-suffering agony prolonged by palliatives continue until the limit is reached in physical and moral misery, until the Island people are completely transformed into a *peonaje de parias, en hato de coolies.* Only death can save us then.[4]

[4] Blanco, "Prontuario Historico de Puerto Rico," p. 151, 1935. See also Barclay W. Diffie and Justini White, "Puerto Rico, A Broken Pledge," 1931.

However, it is the writer's firm conviction and honest opinion that to set the island adrift at the present time would be pathetically tragic to all but the politicians, who always refer to the United States as "the invader." That there has been an *"Imperialismo Industrial"* not in the interests of the people of Puerto Rico is true. That the governors general, to a very large degree, have American interests more in mind than local interests is only too true. That a few kind-hearted Americans refusing to exploit further the poor Jíbaro and his family arouses the ill will of some natives is also true. That some generously minded, far-seeing Puerto Ricans appreciate the seriousness of the situation and earnestly work for the solution of the many problems is most certainly true, and these have no general panacea for the ills of the island; some even see little light ahead. The fact nevertheless remains that on a small island with a population of one and a half million people, where less than half a million should be, with a birth rate twice the death rate and with an increase in population about three times that of the world at large, a change in politics or even independence will not furnish food for the hungry Jíbaro nor clothe his numerous brood. It would seem that the basic hope must lie in an education of the fundamental principle that when four grains of sugar are needed to keep four ants alive, a certain number of days, two grains will keep only two ants alive for a similar length of time. What, therefore, is the solution? Let who can outline a plan.

THE NATURAL ELECTRIC CURRENTS IN THE EARTH

By Dr. O. H. GISH

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ELECTRICAL messages were first received from the earth early in the last century. Joseph Henry in America and Michael Faraday in England had made their notable discovery of electromagnetic induction about a decade and a half before. S. F. B. Morse, just a hundred years ago, had invented the first practical telegraph. Then nine years later, in 1844, the first commercial telegraph-system was put in operation between New York and Washington. In the next few years similar systems sprang up in various parts of the world. When sending messages on these systems there occasionally appeared other signals which sometimes became so frequent and intense as to seriously interfere with the sending of telegrams. A visitation of these intruding signals was usually widespread, coming at about the same time and running much the same course everywhere.

Close observation of the signals which intruded on the lines of the British system led W. H. Barlow to conclude in 1847 that they come from the earth, that such signals may be received at any time, but that they are usually not intense enough to interfere with the telegraph-service. When submarine cables came into use, disturbing signals were also noted on them at the same time as the great disturbances on land lines. Disturbances of this sort were accompanied by erratic agitation of the compass-needle, and frequently by unusual displays of polar lights. These intruding signals constitute the electric messages from the earth which are the theme of this address.

EARTH-CURRENT STORMS

It was soon recognized that these signals resulted from electric currents of some natural origin which circulate in the earth, branch through telegraph-lines, and, when intense enough, actuate the receiving instruments and sometimes even damage them. The occasions when the electric earth-currents are intense and unusually agitated are termed storms, earth-current storms, not because of any connection with weather, for there is none, but rather for about the same reason that an emotional outburst is so designated.

One of the more intense of these storms occurred in 1859. All the grounded telegraph-lines of the world were apparently affected by that storm. During most of a seven-day period from August 29 to September 4 it was impossible to send telegrams. However, occasionally these currents were sufficiently intense and so steady that they could be used instead of the usual batteries for operating the telegraph-instruments. On September 2, the line from Portland, Maine, to Boston, Massachusetts, spanning a distance of 110 miles, was "worked" by the earth-currents alone, commercial messages being sent from 8 to 10 A.M. The line between Fall River and South Braintree, Massachusetts, a distance of 40 miles, was also worked in the same way. A message was also sent in this manner between Philadelphia and Pittsburgh.

In some cases the strength of the current during this storm was roughly determined. Thus it was reported that on one line in France, which spanned a distance of 600 km, the current "was equal

to that produced by a battery of 800 volts." In Norway the disturbance to the telegraph was said to have been greater than in other parts of Europe. During this electric commotion the compass-needle was everywhere visibly agitated. At Rome it changed direction 4° 13′ in a half hour and the horizontal magnetic force changed by one eighth its whole value.

Extraordinary displays of polar lights were also reported. The aurora borealis was seen as far south as 18° north latitude, and at higher latitudes the brilliance of these lights was said to "nearly equal the light of the full moon." Except for the unusual duration and intensity of this storm and the accompanying magnetic and auroral manifestations, this description would apply to many other similar events. The association of the aurora borealis with such disturbances to the telegraph-service has been noted by telegraph operators in some parts of the United States who refer to such an event as an "aurora on the line." However, the relationship is not as direct as that expression would imply.

These impulsive electric messages, which signalize earth-current storms, come only a relatively small part of the time, on the average about sixteen days a year. The rest of the time electric messages of a quite different type may be received—messages of a more tranquil nature which are patiently repeated day after day, year after year. However, the electric currents which convey them are so weak that some care is required to receive them without such distortion as may lead to misinterpretation. Because some aspects of the method of receiving these messages have important bearing on their interpretation, it seems appropriate to describe here some of the essential features of what in technical parlance is called an earth-current measuring system.

Registering Earth-Currents

It was early recognized that systematic observations were required for satisfactorily investigating these phenomena. The telegraph-system by means of which the first evidence for the existence of earth-currents was obtained suggested the gross features of the arrangements used, even up to the present time. The

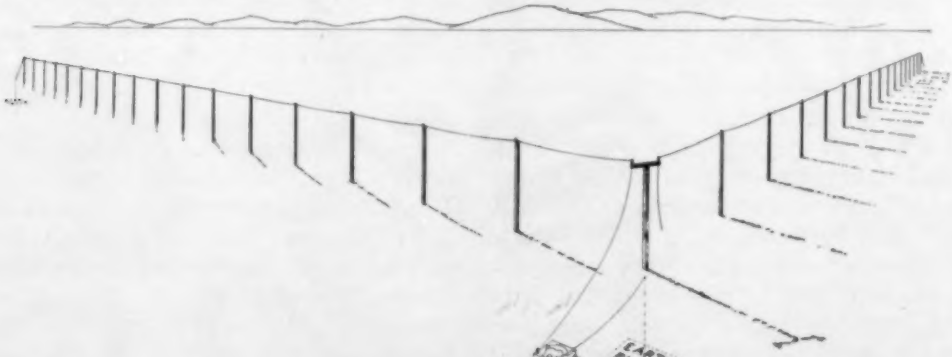

FIG. 1. THE RECEIVING "ANTENNAE"

THE CONSPICUOUS PART OF A SIMPLE ARRANGEMENT FOR "RECEIVING ELECTRICAL MESSAGES" FROM THE EARTH RESEMBLES TWO TELEGRAPH-LINES WHICH EXTEND IN DIFFERENT DIRECTIONS. THESE LINES SERVE ONLY TO CONNECT THE PAIRS OF EARTHED POINTS WITH INSTRUMENTS WHICH REGISTER THE DIFFERENCE OF POTENTIAL BETWEEN PAIRS OF POINTS.

first continuous registration of earth-currents was begun at Greenwich Observatory in 1865 under the direction of Astronomer Royal G. B. Airy.

The arrangement may be described as two special telegraph-lines, with the two ends of each line connected to earth and with a galvanometer substituted for each of the telegraph-receivers. One of these lines extended from the observatory eastward to Dartford, a distance of 9.75 miles; the other from the observatory southward to Croydon, a distance of 8 miles. The contact to earth was made by soldering the wires to water-pipes. The deflections of the galvanometers were registered photographically. From the two components thus registered the direction of the earth-current and the intensity of the impelling force, the potential gradient, were determined. To the casual observer this system would seem equivalent to the most carefully installed modern one (the gross features of such being suggested by Fig. 1), but the reliability of the results obtained from the two different systems may not be at all comparable.

Systematic observation of earth-currents was apparently stimulated by recommendations made by the Electrical Congress which met in Paris in 1881. Soon after this observations were started in France, Germany, Norway, Finland, Russia, Italy and Bulgaria. Bachmetjew, in Bulgaria, used small spans, 80 to 200 meters in length. The longest spans were those in Germany, where the Earth-current Committee used two underground telegraph-cables—one extending from Berlin southward to Dresden, a distance of 120 km, the other extending from Berlin eastward to Thorn, a distance of 262 km. Registration at Berlin began in 1883 and was continued until 1891. The records for the first five years were evaluated and analyzed by Weinstein, whose report stood as the outstanding contribution to the subject for several decades. In 1910 such observations were started at the Ebro Observatory, near Tortosa, Spain, where they have been continued with but little interruption up to the present time, thus providing a body of data of much value.

The net outcome of all these endeavors, as it appeared about a decade ago, may be summed up figuratively as follows: The impulsive messages received at these different places conveyed a fairly consistent story, but the more tranquil messages were not in general agreement, only those received at Berlin and those received at the Ebro Observatory being in fair accord.

Cooperative Activities

Such was the status in 1922 when the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, in order to further its program for investigating the electrical and magnetic phenomena of the earth, installed an earth-current measuring system at its magnetic observatory near Watheroo, Western Australia. Since then this activity of the department has been extended, first by establishing another system at its observatory near Huancayo, Peru, in 1925. Later, through cooperation with the United States Coast and Geodetic Survey and the American Telephone and Telegraph Company, the registration of earth-currents was begun in 1931 at the Coast and Geodetic Survey magnetic observatory near Tucson, Arizona. Registrations were also obtained at College, Alaska, from August, 1932, to June, 1934, through cooperation with the U. S. Coast and Geodetic Survey and the University of Alaska, and at Chesterfield Inlet, Canada, through cooperation with the Meteorological Service of Canada. The data from the two latter stations are of special significance because these places are both close to the Arctic Circle

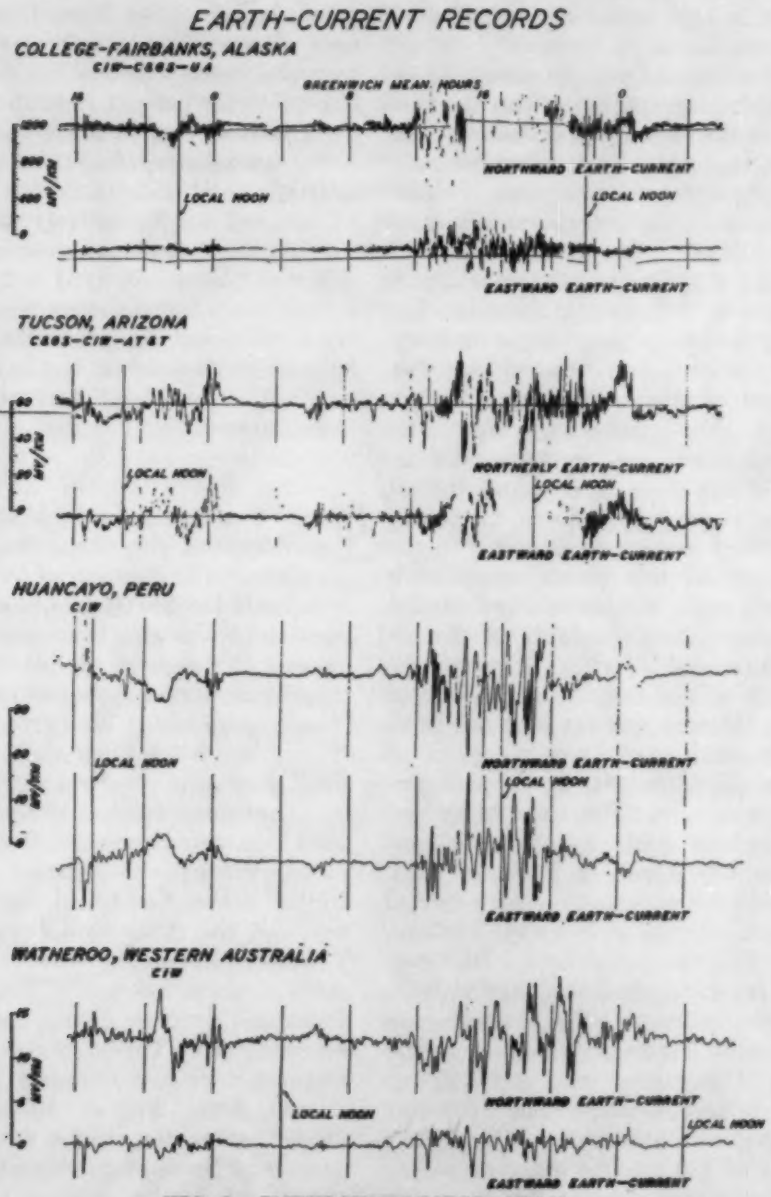

FIG. 2. IMPULSIVE "MESSAGES"

SUCH AS THESE, WHICH WERE RECEIVED APRIL 30 TO MAY 2, 1933, AT FOUR PLACES RANGING IN LATITUDE FROM 65° NORTH TO 30° SOUTH, ANNOUNCE EVENTS WHICH OCCUR SIMULTANEOUSLY OVER THE ENTIRE EARTH.

and because these projects were a part of that remarkable international co-operative program known as the Second International Polar Year.

Telephone and telegraph organizations have naturally been interested in these electric currents for a long time, but as a rule they have made no extended investigation of this class of phenomena. However, the Bell Telephone Laboratories have made a notable exception to the rule by conducting registrations of earth-currents during recent years at a number of places in the United States. Some systematic measurements have also been made during the past decade in Sweden. Dr. G. C. Southworth, of the Bell Telephone Laboratories, in consultation with members of the Department of Terrestrial Magnetism, planned the program and devised the means by which long-distance telephone-lines could be used satisfactorily for this work without interfering with the use of the lines for telephone-service.

The tranquil messages received in these more recent endeavors are in reasonably good agreement among themselves and also with those obtained at Berlin and at the Ebro Observatory. This outcome instills confidence in the technique which has been developed for receiving them.

Striking Correspondence

The information now accumulated enables one to view some of the broader aspects of the system of electric currents which circulate in the earth. One sees that most earth-current storms which are observed in the middle latitudes occur simultaneously everywhere on the earth as illustrated in Fig. 2. Comparing these with the corresponding magnetic records reproduced in Fig. 3, one notices a pronounced similarity in the character of the magnetic and the electric records. When one is disturbed, the other is also disturbed. This, as well as the similarity in the character of the disturbances, is obviously not a mere coincidence.

Correspondence between the occurrence of auroræ and disturbances in earth-currents and possibly solar activity is also suggested by the evidence.

Observations indicate that an electric storm is likely to follow another storm at intervals of 27 days. Although for the aurora the indications are not so positive, yet there appears to be some evidence of a similar recurrence. It should be recalled in this connection that 27 days is the time required for a sunspot to rotate with the sun. A relationship is also found between the variations in earth-currents, the activity of the earth's magnetism and the occurrence of spots on the face of the sun. They all run through a cycle which has a period of roughly eleven years.

When sunspots are numerous, magnetic changes are greater and more frequent, and the earth-currents undergo more intense and more frequent fluctuations than at times when sunspots are less plentiful. From such observations one concludes that these earth-current disturbances must arise out of an influence which is capable of acting directly on the whole earth at once and that the activity on the sun in some way influences the electric currents in the earth.

When one examines the more quiet aspects of earth-currents, he finds that regular changes occur during the day. These undergo some modifications from season to season, and they wax and wane during the years. If the amplitudes of the wave-like graphs representing these changes are charted for different places and different times of the year, it will be seen that the amplitude is a minimum in midwinter, whether the stations be north or south of the equator, and that in general the values for summer tend to be

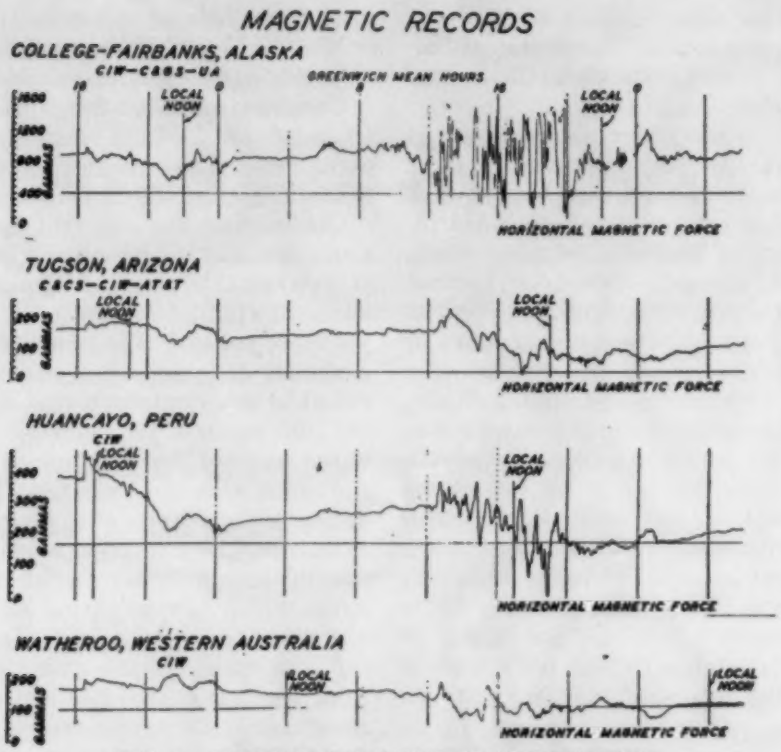

FIG. 3. IMPULSIVE MAGNETIC "MESSAGES"

THE MAGNETIC EFFECTS SHOWN HERE CORRESPOND TO THE ELECTRICAL MESSAGES EXHIBITED IN FIG. 2. THESE APPEAR TO BE MAGNETIC AND ELECTRIC VERSIONS OF THE SAME NARRATIVE.

high, yet there appears to be a tendency for large values to occur near the time of the equinoxes. There is also evidence that the amplitude of daily change varies with a period of about eleven years and that this corresponds approximately with the variations in sunspot number.

EARTH-CURRENTS AND TERRESTRIAL MAGNETISM

When one attempts to ascertain from the data just what relationship exists between earth-currents and terrestrial magnetism, he is confronted with some difficulty. This is especially pronounced in the case of earth-current and magnetic storms. During these storms the changes in the earth-currents are sometimes of the same character as those in the corresponding component of terrestrial magnetism, the two increasing or decreasing in unison (see Figs. 2 and 3). Then again they differ considerably in character, although the duration of the disturbed periods corresponds. If the magnetic changes were due to electric currents in the earth, then they should be roughly proportional to the electric changes; thus the graphs which represent the magnetic changes (Fig. 3) should be about the same shape as those for the earth-currents (Fig. 2).

However, if the magnetic changes produce the earth-currents, the relationship would be quite different. The earth-currents would then be roughly proportional to the rate of the magnetic changes. Thus, even though the magnetic disturb-

ance be large, if it is changing but little the earth-current at the corresponding time would be small. A comparison of the observed storm-changes in earth-currents and in the earth's magnetism therefore seems to indicate that sometimes one relationship holds, sometimes the other.

Viewed superficially, this may be taken to indicate that part of the time the earth-currents are the cause of the magnetic changes and part of the time the result of those changes. This apparent duplicity of character, together with the inconstant nature of earth-current storms, are obstacles which stand in the way of a comprehension of them. Since it is not proposed here to venture far into the free and airy realm of speculation, we shall leave this aspect and turn to a further examination of the relation between the more quiet aspects of earth-currents and the corresponding changes in terrestrial magnetism.

The most conspicuous feature of earth-currents on so-called quiet days is the fairly regular variation during the day. Although the character of this diurnal variation varies with latitude, yet a description of that observed at Tucson, Arizona, about 32 degrees north latitude, will bring out some of the general features.

The currents there are weakest an hour or two before midnight. At midnight they flow south-westward, but steadily veer so that at 2 to 4 A.M. the flow is westward, at 5 A.M. it is northward, then the intensity increases rapidly reaching a secondary maximum at 7:30 to 8:30 A.M. when the flow is north of north-eastward. This is followed by a rapid veering to the eastward and then to the southward reaching the maximum intensity for the day at about 11:30 A.M. to 12:30 P.M. when the direction of flow is toward the south-southwest. The current then decreasing in intensity veers through westward direction at about 3 P.M., through the northward at about 4 P.M. Now increasing somewhat in intensity an evening maximum is reached at about 5 to 6 P.M., the flow then being toward the north-northeast. Then veering toward eastward the intensity decreases to almost nothing an hour or two before midnight. Thus the current runs through two cycles each day. The considerable regularity with which these cycles repeat day after day admits of their being compared quantitatively with the diurnal changes in the Earth's magnetism.

The mathematical relations between the diurnal changes in terrestrial magnetism and those in earth-currents, which should apply if the latter are induced by the former, were first derived by S. Chapman and T. T. Whitehead. The earth-current changes which they thus calculated from the magnetic changes have considerable similarity to some of those which are observed. However, there is a degree of disparity between the calculated and the observed values which can not be disregarded.

Of course the formulae were not devised to take account of those irregularities in the structure of the Earth's crust which present great contrasts in electrical conductivity and thus certainly distort the electric flow. Perhaps the most pronounced large-scale contrast of this nature is that between land and sea, the conductivity of sea-water being several orders of magnitude greater than that of land. Other currents of more or less local extent and of quite different origin may at places be superimposed upon the more general system, thus adding to the complexity.

Furthermore, one should not neglect to question the reliability of the earth-current data, provided those data were obtained in such a way as to give no criteria by means of which it may be

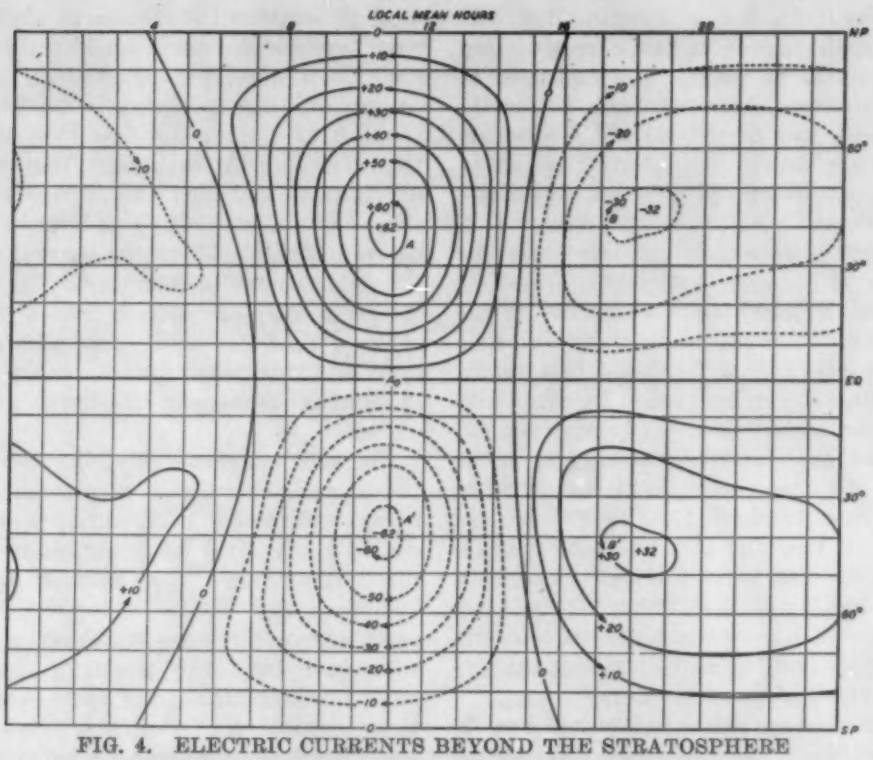

FIG. 4. ELECTRIC CURRENTS BEYOND THE STRATOSPHERE

ELECTRIC CURRENTS FLOWING IN EXTENSIVE EDDIES LIKE THOSE DEPICTED HERE BY BARTELS WOULD ACCOUNT FOR THE AVERAGE TRANQUIL DIURNAL-CHANGES IN TERRESTRIAL MAGNETISM. THIS CURRENT-SYSTEM IS FIXED RELATIVE TO THE SUN AND HENCE THE EARTH ROTATES WITHIN IT. THE WESTERN HEMISPHERE IS HERE SHOWN DIAGRAMMATICALLY.

ascertained that extremely local phenomena, especially such as are produced by the method of measurement, have been eliminated. Such modifying influences may account for some of the disparities. In any case, the induction theory is the only one now in sight that can claim attention.

One may therefore tentatively entertain the view that the earth-currents which are observed are in the main induced by magnetic variations, but that their strength and direction are modified in a manner which varies from place to place and which depends upon the distribution and configuration of oceans and continents as well as upon other structural features of the earth. Modifications produced in the earth-currents by the deep structure of the earth's crust may thus constitute electrical messages which contain information about conditions in that little-known region.

CURRENTS IN HIGH ATMOSPHERE

The magnetic forces which, on the view just outlined, induce the earth-currents have their immediate origin in the high atmosphere in about the same region which reflects radio waves. If a system of electric currents having the character represented by the diagram of Fig. 4 circulates in that region of the atmosphere, it would be capable of producing the daily magnetic changes which are observed at the surface of the earth.

To justify the assumption that there exists such a system of currents or any equivalent which may produce the corresponding magnetic effect would carry us beyond the scope of this discussion, since it is here desired to simply point out somewhat of the mechanism by which the electric currents in the earth may be induced. The portion of this system of currents which appears at the center of the diagram is always directly under the sun and therefore the whole system moves relative to the earth, making a rotation once each day.

The magnetic field of this electrical circulation as viewed from outside of the earth is one which in its principal features does not change appreciably with time, but, since it is moving relative to an observer on the earth, it appears to him to undergo a regular diurnal variation. This magnetic field, together with the earth which rotates within it, constitute the electric machine which generates the electric currents in the earth. Thus one might expect to find in the earth a general system of electrical circulations which is related to that represented for the high atmosphere.

The Great Electric Eddies

It has recently become possible to construct, on the basis of observed data, a world picture of the electric currents which circulate in the earth. This picture shows a number of great electric eddies (see Figs. 5 and 6). Eight of these are located in the middle latitudes, four in the northern hemisphere and four in the southern hemisphere, symmetrically

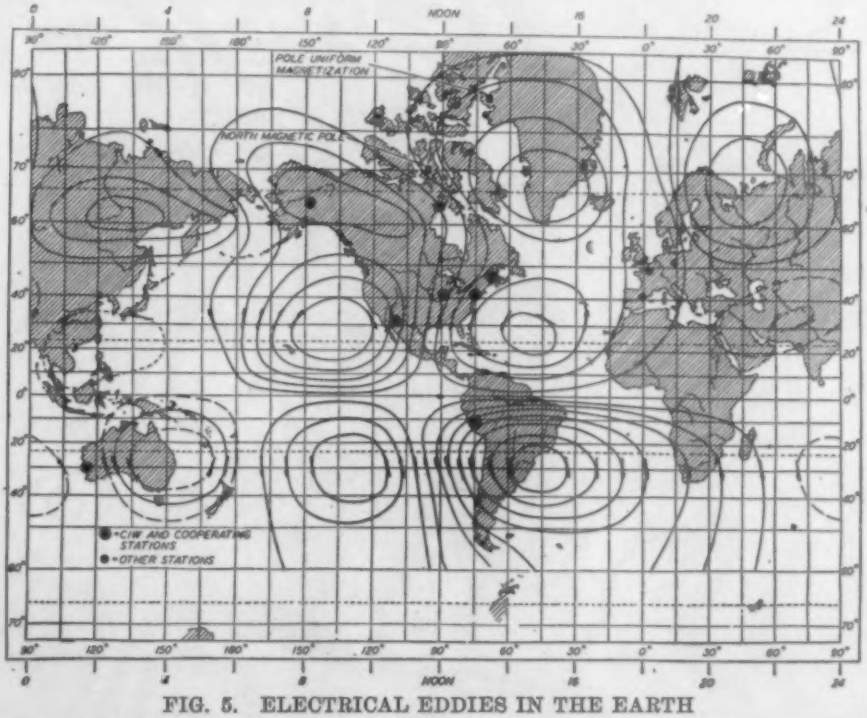

FIG. 5. ELECTRICAL EDDIES IN THE EARTH

The tranquil electric "messages" as interpreted here refer to electric currents which circulate in extensive eddies in the Earth's crust. Those for the daytime over the Western Hemisphere are here shown diagrammatically.

placed on either side of the equator with centers about equally spaced in longitude and lying along a parallel of latitude near the tropics of Cancer and Capricorn (see Figs. 5 and 6). Four more such eddies with centers in the Arctic are also disclosed. Although there are no data to establish the fact, it seems likely that there are also four corresponding eddies in the Antarctic.

All these eddies follow the sun in such a way that there are eight on the sunlit side of the earth and eight on the dark side. The curves which outline the eddies are constructed in such a way that two adjacent curves indicate the boundaries of a tube of flow. Those tubes which are bounded by solid lines all contain the same amount of current except that in the case of the innermost curves the flow is sometimes less than that for a full tube. In order to show some of the weaker eddies it was necessary to subdivide some of the tubes. These are outlined by broken lines. The direction of flow is that of the arrows.

Current-systems corresponding to the charts which are exhibited here would completely account for the average diurnal variations observed in earth-currents

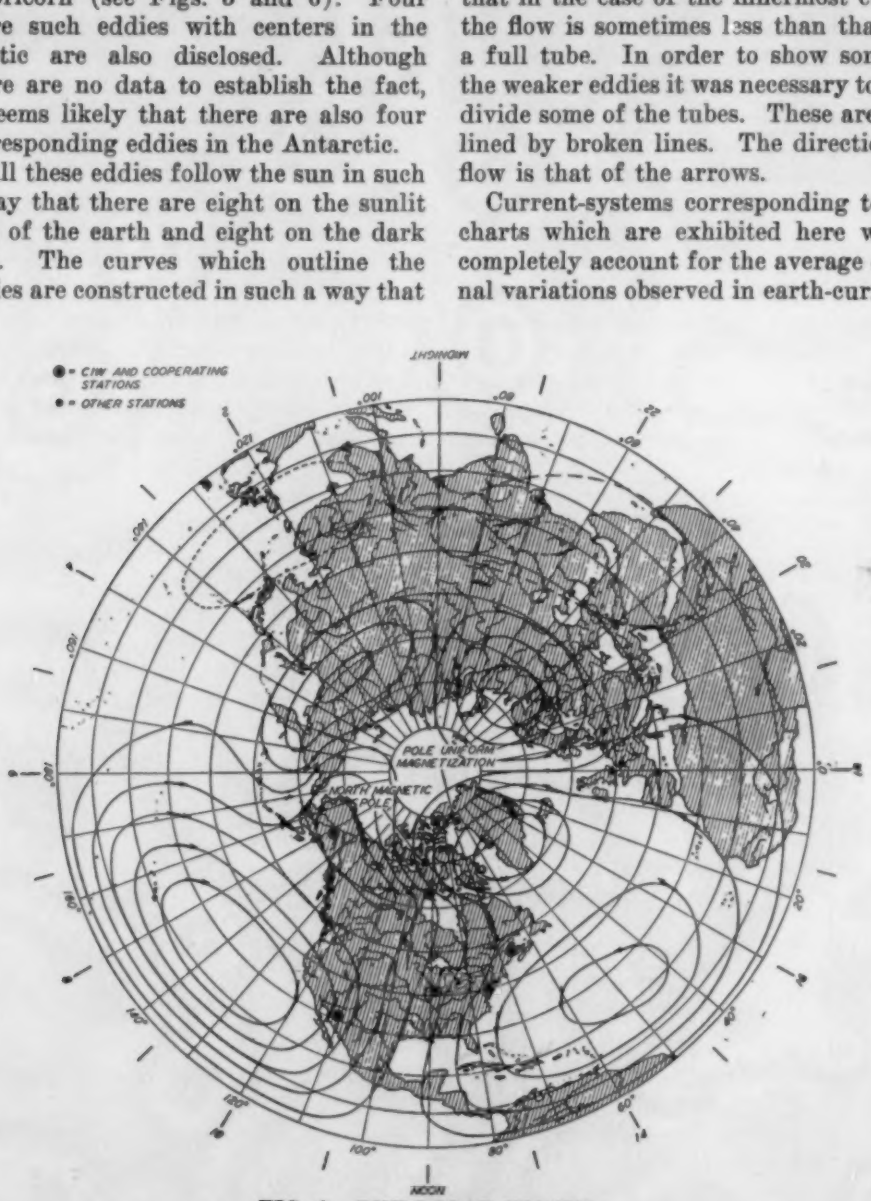

FIG. 6. THE POLAR EDDIES

THE ASPECT OF THE ELECTRIC EDDIES IN THE NORTHERN HEMISPHERE DURING DAYTIME IN THE WESTERN HEMISPHERE.

at Watheroo, Tucson and Chesterfield Inlet. Similar charts have been constructed from other sets of data; in fact, all the principal series of earth-current data have been examined in the same manner, and without exception they are consistent with a scheme having the general features here depicted.

In order that this picture may the better represent the observed facts, the tubes of flow must be regarded as very flexible, easily deformable, so that the shape of the tubes may be readily distorted and even the centers of the eddies displaced in such a way as to conform with the distribution of the electrical properties of the earth, especially of that portion which constitutes the more immediate environment of a given eddy. It also seems likely that the development and the orientation of the eddies should be in some relation to the magnetic axis of the earth. When the general aspects of pertinent earth-current data are viewed in such a perspective they will, it is believed, be seen to be consistent with the principal features of the interpretation which the charts are designed to convey.

Returning again to an examination of the charts, it will be noticed that the current in the daylight eddies is considerably greater than that in the others; at least this is true for the eddies located in the middle latitudes. The centers of the forenoon eddies of the middle latitudes are approximately on the meridian for which the time of day is 9 A.M., while the afternoon eddies center on the meridian for which the time is about 3 P.M. Considerable flexibility must be allowed for this feature. The circulation in the forenoon eddy of the northern hemisphere and that in the afternoon eddy of the southern hemisphere are clockwise, whereas in the other two daylight eddies the circulation is counter-clockwise. A similar description applies to the night-time eddies.

The circulation in the eddies of the Arctic region is in the same sense as the corresponding eddies of the middle latitudes in the northern hemisphere. As these eddies move relative to the earth the direction and intensity of the earth-current at a given place change, those changes depending upon the position that place may occupy in the eddies and hence depending also upon the latitude of the place. This, then, is the world view of the gross aspects of the quiet-period earth-currents—the most comprehensive interpretation thus far made of the tranquil electric messages from the earth. It is, however, but a beginning; much deciphering remains yet to be done.

A THEORY FOR THE MEASUREMENT OF SOME SOCIAL FORCES

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THE concept of social "forces," "acceleration" of a social process, "momentum" of a social movement and some other analogues from physics are much used in sociology with a vague meaning. It is here proposed to define them for scientific purposes as compounds of basic concepts which can be objectively observed, verified and measured. These compounds may be defined by a system of equations using, not sterile analogies, but analogous reasoning to that used in physics.

BASIC CONCEPTS

(1) *Time.* The time aspect of most social phenomena may be expressed in terms of years, Y_{t_1-t} (where subscripts denote terminal dates) as more suitable for social change than the seconds of physics. Other non-solar concepts of social time may describe some social phenomena more adequately (such as "adolescence," "maturity," "old age," etc.), but if they are reducible to quantitative units, they must be transposable into terms of solar years or else be something other than "time."

(2) *Population.* A second basic concept is the size of the population, P, involved in the sample studied. Its unit is the average person in that sample. While individuals in a group vary, yet for purposes of measuring social changes in groups between different dates the mean may represent each group.

(3) *"Indicia."* A third basic concept is that of the "Indicia," I, or units of the index (or "indicator") which measures any quantitatively expressible characteristic of a population. The indicator of a population, to use a term free of the narrower connotation of an economist's "index," may be a mean score on some scale, a death rate, a percentage of illiteracy, a correlation coefficient expressing a relationship of two phenomena in the population, an average expectancy of life, the per capita income of that population or its standard deviation or any other social statistic which characterizes a definite population. For each of the many types of indicators the term sub-indicator, S, may denote the status of, or the value characteristic of, one case within the series. Thus, where the indicator is the birth rate, a sub-indicator is the birth rate of Ohio within the series of the birth rates of the states. The units of such indicators may be termed indicator-units or "indicia" for convenience in dealing with them as a class, as in the compounded concepts to be defined below. An indicator, such as the Chapin scale of socio-economic status, defines a line or a continuum of some characteristic in social space; a sub-indicator, or status, is the position of a certain population on that line specified as at a given distance, or number of indicia, from the zero point or origin. The status will often be a ratio whose denominator is P, as in an average score

$$S = \frac{\Sigma I}{P} \qquad (1)$$

or a divorce rate *per* thousand, or a *percentage*[1] of foreign born. It should

[1] The indicia here are not numbers of persons but successive categories of crude two-category variables, "divorced—not-divorced," "foreign-native." Giving the two categories of this variable value of one or nothing, the per cent. divorced is the *mean* of the variable as it is the average of the values of the variable, each value multiplied by the frequency of cases at that value.

not be an absolute number of persons, such as the number dying in a country, as then S ceases to be so clearly a characteristic of, or related to, the whole population, P, and confusion results between S and P when they are later compounded in the concepts of momentum and force.

Compound Concepts. With the three fundamental types of units, years, population and indicia, further compound units may be readily derived to describe social phenomena.

Social Change. A difference in the status of a population on two different dates, i and ii, can measure the social change that has occurred in the period, in so far as the indicia are appropriate and accurate. The formula is:

$$C = S_{ii} - S_i \qquad (2)$$

Velocity. The time rate with which a social change goes on may be expressed as the units of change divided by the number of years in which the change occurs

$$V = C/Y = (S_{ii} - S_i) \div Y_{ii-i} \qquad (3)$$

Thus if the percentage of unemployed in a defined population fell from 15 per cent. in 1932 to 10 per cent. in 1934, the annual speed of change would be $.05 \div 2 = .025$ indicia, where indicia are percentage units.

Often the indicia are not of this static sort whose amount on a given date can be determined, but are of the dynamic units of change or process itself as, when they may be defined acts or events, in time. Thus the social process of communication may have the velocity of its telephonic component measured by defining an indicium as one telephone call. The number of telephone calls occurring for a year, then, is the velocity of this social process. Of course this is alternatively expressible as the total number of calls, since some arbitrary date, at the beginning of the year, S_i, subtracted from the total number at the end of the year, S_{ii}, giving the change or amount of the process occurring in that unit period.

This average velocity for a period between date i and date ii can be more accurate in the rare cases where a curve has been found to fit the data well, as then the derivatives of the equation of the curve give the velocity of change at any date within the period.

Acceleration. The velocity of social change, or the speed of "progress" may itself be speeded up (or slowed down). This acceleration, or rate of change of velocity, is measurable as the difference in two observed velocities divided by the time interval

$$A = (V_b - V_a) \div Y_{b-a} \qquad (4)$$

Thus, if the quota of a Five Year Plan is increased during the period, progress in that respect may be accelerated.

Population-change. A concept, not used in physics, but which may be useful in social phenomena, is that of a population changed a certain amount irrespective of any time taken. Sometimes the terminal dates for a measurable change are not determinable. This concept of population-change is measurable as their product

$$Pc = P \cdot C \qquad (5)$$

The unit of population-change is one person changed one indicium, as in a child promoted one school grade or one person changed one point of score on an attitude scale.

Momentum. Another current phrase is that a social movement "is gathering momentum" or "headway." This concept may be precisely defined as the product of the velocity of change and the population changed,

$$M = VP. \qquad (6)$$

Thus a movement may increase its momentum extensively by drawing in more people or intensively by increasing the speed with which a given group is be-

ing changed. A consumer's cooperative movement may increase its momentum by either getting more people to participate or by getting its clientele to buy a larger per cent. (indicia) of all their purchases from the cooperative store. Again a mass movement for non-cooperation in India which in its boycott cuts purchases of foreign goods x rupees per capita annually among 100,000 adherents has half the momentum of one which either cuts purchases twice as much or doubles the number of adherents.

Force. A social force may next be defined as *all that which accelerates social change in a population.* It is measurable as the product of acceleration and population

$$F = AP = \left(\frac{S_{iv} - S_{iii}}{Y_{iv\,-\,iii}} - \frac{S_{ii} - S_{i}}{Y_{ii\,-\,i}}\right) \frac{P_i + P_{ii} + P_{iii} + P_{iv}}{2Y_{(iv\,+\,iii\,-\,ii\,-\,i)}} \quad (7)^2$$

noting that the average population of the surveys at different dates is used in case the ideal experimental technique of measuring only the identical individuals has been impossible.

Social forces may be physical, biological or social in origin, but as they stimulate the neural system in some way whether internally or externally, the unit of social force might be christened a "stim," a unit of total stimulation. A "stim" is defined as one person changed one indicium per year per year. It is thus relative to the particular kind of indicator measuring a social status or a change.[3] For some purposes the status may be compared with the similar status of another country, but for administrators the time rate of changing the status and the inertia due to the size of the population are important factors and a single measure combining all three, as force does, may be a useful summarizing concept.

Other concepts may be compounded on the model of work, energy and power. But these seem to have less utility for social phenomena. The physical terms should not be borrowed unless they offer real clarification in thinking about social phenomena.

Probable errors. The formulae for the standard errors of sampling for the above concepts are as follows;[4] derived by the usual process of differentiating both sides of equations (1) through (7), squaring, summing and dividing by N, where Y and P are considered to be constants:

$$\sigma_c^2 = \sigma_{s_i}^2 + \sigma_{s_{ii}}^2 - 2r_{s_i s_{ii}}\,\sigma_{s_i}\,\sigma_{s_{ii}}$$

the usual σ of a difference where σ_s may be that of a mean, a percentage, or whatever the sub-indicator is (8)

$$\sigma_v = \sigma_c / Y \quad (9)$$

$$\sigma_a^2 = (\sigma_{v1}^2 + \sigma_{v2}^2 - 2r_{v1v2}\;\sigma_{v1}\,\sigma_{v2})/Y_{2\,-\,1}^2 \quad (10)$$

$$\sigma_{cp} = P\sigma_c \quad (11)$$

$$\sigma_m = P\sigma_v \quad (12)$$

$$\sigma_f = P\sigma_a \quad (13)$$

where

$$R_{v1v2} = Rc_{ii\,-\,i}\;c_{iv\,-\,iii} = R(s_{ii} - s_i)(s_{iv} - s_{iii}) = \frac{-R_{s_{ii}s_{iv}}\sigma_{s_{ii}}\sigma_{s_{iv}} - R_{s_{ii}s_{iii}}\sigma_{s_{ii}}\sigma_{s_{iii}} - R_{s_i s_{iv}}\sigma_{s_i}\sigma_{s_{iv}} + R_{s_i s_{iii}}\sigma_{s_i}\sigma_{s_{iii}}}{\sigma_{c_{ii\,-\,i}}\,\sigma_{c_{iv\,-\,iii}}} \quad (14)$$

and where $r_{S_a S_b} = r_{I_a I_b}$ the correlation between means (when S is a mean) being

[2] Note that to determine acceleration the status of a group must be measured on a minimum of three separate dates (date ii may coincide with iii in the formula above). The velocities are average ones for the two periods ii–i and iv–iii and so are best taken as the velocities at their mid dates $\frac{ii+i}{2}$ and $\frac{iv+iii}{2}$, which are denoted by the subscripts a and b, respectively.

[3] For an example of "stims" worked out and compared in an experimental and in a control group, as well as for a fuller statement of this theory see: Dodd, S. C., "A Controlled Experiment in Rural Hygiene in Syria," American Univ. of Beirut, Syria, pp. 207–222, 1934.

[4] Acknowledgment is due to Professor T. L. Kelley for assistance in checking over these formulae and their assumptions.

the correlation between the variables (indicia) under conditions of random sampling.

Diversity of the Indicia. Since there are many kinds of index units, each appropriate for some social characteristic, there will be a corresponding diversity of "stims" and other compounded units. The compounded units must always have an accompanying specification as to the indicator involved (as well as the period and population where these are called for). "Stims" (and other compounded units similarly) will be comparable only when based on the same kind of indicia.

In order to systematize the diversity of indicia there are at least three techniques that may be of service. The first is to list all the types of indicia and attempt their classification on some suitable basis, or alternative bases, in order to reduce them to a smaller number of orderly categories. A second technique is, wherever possible, to find and express diverse indicia in common units, as percentages or indexes of a common base, as standard deviation units, etc.

A third technique is that of factorial or vectorial analysis of the observed variables (indicators) under the limited conditions where all their intercorrelations are securable. Considering each indicator as a vector, the angle between every pair of them in n-dimensional social space is given by the correlation coefficient as the cosine of that angle. Thus if two indicators, hygienic score and income, have a correlation of .50, the angle between their vectors is 60°. By determinantal algebra it is possible to transform these n vectors, representing the n observed sets of indicia, into n other orthogonal vectors (which are all mutually at right angles to every other vector), or, under certain limiting conditions, into less than n other vectors (or "general factors"), either orthogonal or oblique, as desired by the investigator. This realization of the principle of parsimony has the advantages that the observed interrelated variables are analyzed into categories or factors which fulfil the canons of classification in that they are (a) mutually exclusive (if orthogonal), (b) totally inclusive (of all the phenomena) and (c) have mathematically defined boundaries. The disadvantages are that: (a) usually no *unique* analysis is possible; (b) where alternatives exist, the choice of the "best" analysis is somewhat arbitrary still; (c) the mathematics are difficult and uninterpretable by persons untrained in these concepts; and (d) the theory is still under development with the usual controversies over issues that frontier on the unexplored. Nevertheless, it may become a powerful tool for analyzing and systematizing diverse sociometric phenomena.[5]

Resisting Forces and Other Auxiliary Concepts

A force as defined above is a net force, *i.e.*, that part of the stimulation which produces an acceleration of a social change in a population in addition to overcoming whatever resisting forces there may have been in the total situation. The problem of measuring these resisting forces, F_r, which resist the force, F, at issue (such as attitudes glorifying war which resist pacific propaganda) is one of developing indicia for the supposed resisting forces, measuring them, correlating them with the force at issue, and analyzing out of the vectors the positive, negative or neutral components which show the degree to which the hypothesis that F_r was resisting F is true or false.

A force should not be confused with a *cause*. Force is here defined, as in physics, in terms of effects "that which *has* accelerated a population." The nature of the partial causes of this measured effect, or total force, is a further problem

[5] Full exposition of this vectorial analysis may be found in "The Vectors of the Mind," University of Chicago Press, 1935.

in measurement or at least in forming hypothesis depending on the knowledge and insight of the investigator.

A *factor* denotes correlation with whatever variable it is a factor of; it may or may not be a cause.

An *agency* is the human and/or material organization which stimulates a group, *i.e.*, which generates a force, just as an engine does in physics.

Newton's Laws of Motion. The concepts may be further clarified in the form of a paraphrase in social terms of Newton's three laws of motion. Without asserting any metaphysical assumption about the nature of social phenomena, the paraphrases may be taken as a convention to define terms, a frame of reference, arbitrary perhaps, but useful as a standard to fix meanings of other concepts and units relative to that frame. The paraphrases are:

(1) Whatever changes the status of a population or its process (or changing) in rate or direction, is called a social force.

(2) Change of rate of a social change or process is proportional to the social force and takes place along the line defined by the indicia in which the social change is measured.

(3) Forces and their total resistances are equal and opposite.

The first principle takes the existing static or dynamic state of a population as the zero point of a frame of reference and uses departures from it to define forces. Instead of the existing state any other could be taken, but how choose which of innumerable possible states of change to take as the standard? There is only one existing state at a particular moment, so that choosing it as origin of a frame of reference is logically compelling. There is no metaphysical assumption of inertia, *i.e.*, that the "normal" nature of society is to be in its present status or rate of change; it is merely a choice of coordinates which enables defining other concepts.

The second principle defines the units of force in terms of the units of the social change involved and points out their vectorial nature in having both amount and direction.

The third principle enables an equation of balancing all the positive and negative forces of a given kind, whether identifiable or not, that are acting on a population.

Finally, a warning as to some of the limitations of this system of concepts may prevent their misuse.

(1) These concepts should not be interpreted as implying a mechanistic conception of society; they are intended merely as definitions of some compound units for more precise expression of those few social phenomena in the very limited sector where basic units measuring social characteristics have been devised.

(2) The derived units are no better than the basic indicia; if these are inappropriate, inaccurate or inadequate for measuring the characteristic of which they are indices, the derived units will be bad ones in consequence. The essential problem is to get good indicia.

(3) In addition, the velocity, acceleration, force, etc., are in the nature of averages or trends for the periods specified. They oversimplify the situation wherever more detailed knowledge of variations is needed; they summarize net results obscuring analysis of component parts and neutralized resistances.

(4) The probable error formulae for interpreting the significance of observed quantities are based on the assumption of random sampling—an assumption which may not be tenable in a given set of measurements.

(5) The concept of indicia should not lead one to treat the diverse kinds all alike. It should lead to deeper study of statistics to learn the properties of each kind and the limits of their appropriate manipulation and interpretation.

THE SOYBEAN POINTS THE WAY TO AGRICULTURAL RECOVERY

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WHILE in ancient Rome the ballots were usually cast by black or white beans, it seems very likely that in the present transitional stage of our country another bean, the soy, is destined to play a decisive rôle as an example of a constructive and practical way towards the restoration of the buying power to the American farmer—a *sine qua non* for the return of prosperity to the United States.

While agriculture's chief purpose merely consists in converting the unmarketable water, air and sunshine, as well as the minerals of the soil, into marketable products through the application of labor, tools and the use of various farm animals, it is evident that lasting agricultural prosperity is dependent upon further application of labor and machinery, namely, upon the development of industrial uses for farm products which would take care of the existing surpluses and create a continuous demand for agricultural raw materials.

The soybean is a vivid example of a crop with an amazing diversity of industrial uses. As yet, however, we are only beginning to suspect the extent of the potentialities which further scientific research may discover and which commercial development may transform into actualities.

The 20 per cent. of oil contained in soybeans was the main factor responsible for their becoming popular with the oil millers. In 1934 soybean oil constituted 11.6 per cent. of the world's production of vegetable oils. The United States production of soybean oil for the same year amounted to 1.6 per cent. of the total U. S. production of vegetable oils, constituting about 2.5 per cent. of our domestic cottonseed oil—a 2.5 times increase in the ratio soybean oil/cottonseed oil since 1930.

According to official figures, in 1935 American farmers planted 5,463,000 acres in soybeans grown alone. There was also a large acreage grown with corn and other crops for forage. The soybean crop in the six important bean-growing states—Ohio, Indiana, Illinois, Iowa, Missouri and North Carolina—is estimated at 33,541,000 bushels, nearly twice that of 1934 and three times the six-year average (1928–33).

The total quantity of domestic soybeans harvested in 1935 is placed at 39,637,000 bushels. Allowing 10,600,000 bushels of soybeans for seed, feed and other farm uses, over 29,000,000 bushels are available this season for crushing, export and carryover, compared with the 8,660,000 bushels crushed from the 1934 crop. Trade reports indicate that during the last part of 1935 soybean mills have been working at near capacity. Some cottonseed oil mills are also crushing soybeans in considerable volume, turning out old process, hydraulic type oil meal.

The hydraulic press system possesses the disadvantages common to all discontinuous processes, mainly, the large labor requirements and losses of time in charging and discharging the presses. The Anderson expeller was developed to meet the need for oil-producing equipment, which is continuous in its operation. The expeller, once started, requires very little attention, one man being able to care for several machines.

The disadvantage of the expeller is a larger power requirement than the hydraulic press method. Soybean meal output this season may be considerably larger than the record production during the last year, which totaled 223,000 tons.

Where the oil milling is done by the hydraulic press or the expeller method the oil comprises only about one seventh of the weight of the beans, while the cake or meal comprises approximately six sevenths. The demand for soybean meal has been for years the limiting factor for the expansion and volume of activity of our domestic oil milling industry. This meal is being used almost exclusively for feeding live stock, competing with our cottonseed and flaxseed meal, the market price for which is a major basis for determining the price to be paid for the new soybean crop. The price at which beans of the 1935 crop have been contracted by the soybean oil mills was thus set at 75 cents per bushel, and trade reports indicate that soybean oil mills have been working since at near capacity.

Figures, compiled by the Illinois State Agricultural Experiment Station, show that for five years (1927–31) the average yield per acre of gathered soybeans amounted for the whole United States to only 13.8 bushels per acre, with Illinois leading at 16.2 bushels per acre and Iowa following with 15.9 bushels per acre. It means that in 1935 the soybean grower was receiving in Iowa only $12.00 gross income per acre, while the cost of growing soybeans was estimated (for 1933) by the Iowa State Agricultural Experiment Station as $16.56 per acre (labor being calculated at 20 cents per hour). Even at a yield of 20 bushels of soybeans per acre the gross income at 75 cents per bushel would amount to only $15.00. It is therefore evident that the 1935 crop year brought the soybean grower in the central states a net loss per acre of $4.56 (at a yield of 16 bushels per acre) or of $1.56 (at a yield of 20 bushels per acre), the loss being proportional to the number of acres under soybean cultivation. In a 1935 Iowa State College publication it is estimated that with a yield of 20 bushels per acre soybeans would have to be sold for about $1.10 a bushel to return the same profit as corn.

It is evident that in order to bring about an increase in the price for the millions of bushels of soybeans crushed as well as to create a demand for additional millions of bushels and to make soybean growing a paying proposition it is necessary to remove the major part of to-day's soybean oil meal from the highly competitive and crowded feed channel and to convert it into products of higher market value. Such a move would also have a favorable effect on the price for cottonseed and flaxseed meal, thus helping in the recovery of another agricultural commodity. It is understood that where the soybean oil milling is being carried out from local beans by smaller rural mills and the meal is consumed for feeding the farm stock of the local district, the disposal of the meal could take place through the feed channel, since in such an instance the costs of transportation and marketing would be greatly reduced, thus enabling the rural oil miller to sell the meal at a reduced price to the bean-grower either directly or through the local feed mixer.

The three main industrially valuable constituents of soybean press meal are: the protein, over 40 per cent; the Phosphatides (Lecithin and Cephalin), from 2 to 3 per cent.; and the oil, about 5 per cent.

The soybean protein ("Glycinin") resembles in its properties the casein of milk. It is liquefied by solutions of weak alkalies and is precipitated from solutions by acids, the isoelectric point being a pH of about 5.4. This property of soybean Glycinin can be used by the

Food Administration for the quantitative estimation of soybean flour or meal in sausages. Adequately processed, soybean meal is suitable for mixing up to 50 per cent. in all kind of sausages which can be sold at a substantially reduced price, thus helping the meat packers to expand the volume of meat consumption by reaching customers who would not have the means to buy pure meat sausage.

When hydrolysed by acids or enzymes, soybean protein is converted into soy sauce, which is used for bouillon extract preparations and has been for decades the base of Worcestershire sauce. Brewers have recently become interested in soybean protein for increasing body in beer.

Glycinin possesses the property to form water — insoluble "glycinates" (similar to the "caseinates" of milk) with the metals of alkaline earths as well as with aluminum and the heavy metals. When glycinin is treated with formaldehyde it is converted into a thermoplastic resin. Briefly, soybean protein is capable of taking the place of casein (which is much more expensive and is being imported to the U. S.) in a large number of industries, such as sizing for paper, glue (waterproof) and plastics, all of which are already in existence in our country. At the 1933–34 International Exposition in Chicago all exterior walls and sub-floors of the Hall of Science were constructed of plywood panels glued with soybean glue. To-day soybean meal is used by the Ford Motor Company for the manufacture of horn buttons, gear shift lever balls, light switch handles, distributor bases, distributor cover and window trim strips. When great resistance to moisture or high dielectric strength is desired, resins are produced by the simultaneous condensation of the soya proteins and phenol or urea with formaldehyde in the presence of cellulose and carbohydrates. With the completion of the new $5,000,000 River Rouge plant for soybean plastics, the use of soybean meal will extend to making dashboards and probably also automobile bodies.

As early as 1915 a United States Patent was granted to Dodd for making plastic materials from soybean meal, followed in 1917 and 1918 by a whole series of patents issued to Satow. To-day their term has expired and the road is open to ambitious manufacturers to use soybean meal for the manufacture of soybean protein itself (called incorrectly "casein"), of plastic materials from the protein, wall board, floor cover compositions, insulating compounds, artificial leather, etc.

In recent times a method has been devised for hardening and strengthening iron and steel by exposing the heated metal to a composition containing 90 per cent. of soybean meal mixed with various salts. It is claimed that this method of hardening requires only one tenth of the time required for the same purpose by the usual methods.

Soybean meal has attracted much attention as a base for water paint (in combination with caustic lime) which is being recommended for farm buildings, fences, garages, advertising boards, depots, etc. It would make an excellent whitewash material for painting the middle line of our highways, its guard fences, marks, danger signs, etc., due to its cheapness and water resistance.

Soybean meal could find a large outlet in the building of our roads, since it is an emulsifier for asphalt and coal tar. It has also been recommended, in combination with alkalies, as an emulsifier for mineral oils for dormant spray purposes, for copper spray mixtures (Bordeaux), etc. Soybean meal is a valuable protective colloidal mixture and an adhesive as well as an emulsifying agent. The latter property is due largely to the presence in soybean meal of a comparatively large percentage of

phosphatides of the lecithin type (cephalin's emulsifying properties are not sufficiently known).

In a general way lecithin seems to act on fats as a protective colloid, and it tends to prevent the separation of fractional constituents. When cooled, liquefied fats containing lecithin solidify to a homogeneous mass. One million pounds of commercial soya phosphatides are used annually in the margarine industry of Germany, and the other applications of lecithin include the baking and confectionery trades and the textile industry. Being an excellent emulsifier and possessing a high fat-liquoring value, soya lecithin is particularly valuable for the leather industry, causing an increase in the absorption of grease by the leather and permitting the use of higher temperatures. Soya lecithin is also an excellent leather softener and penetrates the hide and becomes partly fixed in it and can not be later washed out as easily as the sulfonated oils. Recently the rubber industry has begun to use soybean lecithin for milling rubber to powder as well as for certain rubber compositions.

Soya phosphatides (lecithin as well as cephalin) are shown to possess antioxidant properties, and in amounts of from 0.05 to 0.1 per cent. are capable of "protecting" edible fats and oils from rancidity.

While the emulsifying properties of lecithin are well established, those of cephalin are not, and it is desirable to change the existing commercial habit to label as "lecithin" mixed soya phosphatides which consist *de facto* of only about 40 per cent. of lecithin and 60 per cent. of cephalin. Cephalin, under its own name, has every chance of becoming a commercial success in its field, while at present it is in many instances a liability.

Up to recent times commercial soya phosphatides have been imported to this country from Germany and Denmark, and during the depression years of 1930–33 its sales showed a steady gain. At present some domestic soya "lecithin" has appeared on the market. It took our industries ten years to establish the first working soya phosphatides extraction plant since the first U. S. patent on soya lecithin extraction and purification has been granted to Bollmann in 1923. While hen's eggs and the soybean oil meal contain approximately equal amounts of phosphatides, the market price for the latter is from ten to twenty times cheaper than for egg lecithin, thus opening a much wider range of possible commercial applications. At the existing market price (about 50 cents per pound of the technical grade soya phosphatides containing 40 per cent. of oil vehicle) an additional income of about 50 cents per bushel of soybeans (as well as from the meal derived therefrom) is assured to the progressive manufacturer. It is surprising to notice that in the 1930 official booklet on soybean oil meal, issued by our National Soybean Oil Manufacturers Association, soya phosphatides are not even mentioned among the components of the meal.

The phosphatides can be separated from the soybean (as well as from the oil meal) only by the extraction (solvent) method, and the developing of soybean extraction is one of the major problems which is confronting our soybean industry. Against our yearly volume of 5 million bushels of crushed beans Germany used in 1931 a volume of 37 million bushels and in 1932 as much as 44 million bushels, all soybeans being imported from abroad and handled by the solvent process which separates the three main commercially valuable constituents of the soybean, the protein meal (flour), the phosphatides and the oil. Extracted soya meal has a number of industrial applications for which press meal (still containing 5 per cent. of oil) can not be used.

In our country extraction is only in its infancy, because of the absence, up to recent times, of a low-priced dependable continuous extraction unit simple and safe to handle, as well as to the lack of printed information dealing with solvent extraction, the organic solvents (hydrocarbons and chlorinated hydrocarbons) and their safe handling, the further procedures in separating and refining the phosphatides and the commercial outlets for soybean extraction materials. Very few U. S. patents are dealing with these problems, and they are to-day an open and promising field for the research worker and the industrialist alike.

By the extraction method less oil is left in the meal to be sold at the meal price of 2 cents per pound instead of the oil price, 9.25 cents per pound. This difference on a twenty bushels per acre yield of beans, containing 18 per cent. oil, amounts to $2.27 per acre on a ten-ton per day plant, or $11,350 per year.

In 1934 our domestic soybean oil has been absorbed by the following trades:

Compounds and vegetable shortenings	2,735,000	pounds
Oleomargarine	24,000	"
Other edible products	509,000	"
Soap	1,354,000	"
Paint and varnish	10,451,000	"
Linoleum and oilcloth	2,843,000	"
Printing ink	59,000	"
Miscellaneous products	2,109,000	"

To-day the edible oil outlet is consuming 90 per cent. of the total domestic soybean oil produced, due to the advantage over other oils in rancidity resistance, better color and satisfactory price. It is regrettable that the industries using soya oil for margarine, salad oil and mayonnaise never make mention of soya oil as a constituent of their products.

The press — expeller — and solvent-extraction soya oil, when refined, is equally good for use in the paint industry. Expeller oil contains traces of phosphatides and solvent-extracted soya oil is rich in these constituents which, unless removed, act as retarders of oxidation.

About twenty years ago, H. A. Gardner, the present director of the Institute of Paint and Varnish Research, demonstrated that through heat treatment and the use of proper dryers raw soybean oil may be dried almost as rapidly as boiled linseed oil. The drier combination that produced the best results were a mixture of manganese linoleate (0.03 per cent. Mn), cobalt linoleate (0.01 per cent. Co), and lead linoleate (0.20 per cent. Pb).

The valuable natural properties, elasticity and flexibility of film and non-yellowing, are best utilized when soybean oil is polymerized. Soybean oil has also been recommended for grinding paste colors. To-day, in the state of Illinois one out of every ten farmers has one or more buildings painted with a paint containing up to 33 per cent. of soybean oil in the vehicle. This has been achieved through good quality soybean oil paint and a reasonable price, through the cooperation of the State Agricultural Experiment Station and the example of the state administration who painted with soybean oil paint the state building at the Chicago Fair as well as the governor's executive mansion.

In 1934 the soybean used in our paint trade was only 2.8 per cent. of the total amount used in that industry. Further development and expansion along this line seems desirable, since present annual importations of flaxseed are amounting to about 500 million pounds, which corresponds to about 150 million pounds of linseed oil (37 per cent. of the total production). Linseed oil and soybean oil are quoted to-day on our market about at par, while in the past soybean oil was always quoted a few points below linseed oil. Considering that excise taxes on imported oils are

rapidly rising, the domestic paint industry will directly benefit by developing a domestic source of supply for its raw materials.

Soybean oil has found an application as a core sand dry bond, and its possibilities as a basis for "cutting oil" are being studied at the University of Michigan Engineering School, both fields being to-day dominated by linseed oil.

At present soybean oil and its acids, as well as glycerine, are used fairly extensively in a number of alkyd resins which are sold under various trade names, such as Glyptal, Rezyl, Dulux, Beckosol, etc. The Glyptal type synthetic resins are used by practically all varnish factories and to a large extent by the lacquer industry. One distinct advantage of these resins is their durability, their aid in retention of tint values and high gloss.

In high-temperature bake enamels the gloss, durability, adhesion and flexibility of enamels made with soybean oil in conjunction with synthetic resins of the all-phenolic type has led to tremendous increase in the use of soya oil. The oil has the advantage of being much cheaper and more readily available from domestic sources than tung oil. High-bake enamels of this kind open up new fields of use for the varnish manufacturer. They have the elasticity and toughness which is desired in a lacquer film and at the same time have water-resistance and alkali-resistance which can not be obtained with ordinary lacquer or quick-drying enamel. The flexibility of these films also opens the possibility of producing more suitable wire enamels which do not soften so readily under heat, and which when wound under tension, will not cause short circuiting due to the softening of the varnish film.

Our automobile industry is to-day using large quantities of synthetic resins and enamels where soybean oil is one of the constituents. A finish for automobile bodies was developed by the Ford Motor Company, employing soybean resin as a coating and soybean oil as a carrier of pigment.

The value of soybean oil for the synthetic resin and high-temperature bake-enamel development was largely due to the fact that this oil contains about 50 per cent. of linoleic acid. The presence of this acid makes soybean oil well adapted also for the manufacture of linoleum as well as soft soap where linseed oil is at present still a major ingredient. Soaps (hard as well as soft), containing soybean oil, are known to withstand hard water very well without impairment of their lathering capacity which view is contrary to the much advertised statement that coconut oil or palm kernel oil are absolutely essential in soap which is employed in waters having any degree of hardness. For this reason soap manufacturers could use soybean oil to a much larger extent than they do to-day, and it should be remembered that in 1917 over 124 million pounds of soybean oil have passed through the kettles of our soap industry for hard and soft soap alike (some of it after being hydrogenated). During the post-war period our automobile variety of soft soap depended largely upon soybean oil. If the Guffey-Dockweiler Bill, permitting duty-free imports of coconut oil to the United States for soap-making, is passed, it will substantially damage the cause of our soybean grower. While the price for an oil or fat is undoubtedly an important factor where a large percentage of the material is used, it is still advantageous and profitable to incorporate a smaller percentage of a more expensive oil when the quality of the soap is substantially improved by it.

Some years ago soybean oil was converted into an effective and comparatively cheap waterproofing substance. It is a viscous yellow liquid which is

mixable with cement and does not affect its strength. It stands sea water exceedingly well. Its uses are numerous—for foundation work, basements, roof gardens, tunnels, bridge piers, reservoirs, cement pipes, etc. It prevents effectively the corrosion of steel skeletons in reinforced concrete.

In reviewing the industrial uses of the soybean the food angle should not be overlooked. During the last decade edible whole flour is steadily gaining in popularity. With the beany taste removed by distillation and the keeping quality enhanced, a high concentrated and palatable product is available which in quantity and quality of protein, as well as in fat, possesses double the value of lean beef, and which in addition contains over 2 per cent. of phosphatides, nearly all the known vitamins and an ash of high alkalinity, while containing neither starch nor gluten. In amounts of 20 per cent. of the mix, whole soya flour is an ideal supplement to wheat for bread and macaroni products, and could be responsible for the shifting of wheat products from the class of energy-producing foods to a level of full-value foods. Soya flour is the miller's best friend and may help wheat to recover some of the 20 per cent. decrease in wheat consumption which took place in our country during the twentieth century as a result of the substitution of machinery for manual labor as well as the advent of the automobile.

It seems evident that to-day the soybean is one of the most promising agricultural plants for an almost unlimited variety of industrial uses, most of them non-competing with existing domestic products, and as such offers the broadest outlook for making farming a paying proposition. The cultivation of soybeans as a cash crop has every chance to expand far beyond the existing commercial level, which will no doubt create numerous new industries and by this do its share in relieving unemployment. The soybean thus seems to point towards a practical and constructive way for many a crop which, through the lasting efforts of all concerned, may lead to the ultimate well-being of the farmer, the workman and the business man alike.

THE EFFECT OF CRUDE OIL POLLUTION ON OYSTERS IN LOUISIANA WATERS

By Drs. PAUL S. GALTSOFF, HERBERT F. PRYTHERCH, ROBERT O. SMITH and VERA KOEHRING

U. S. BUREAU OF FISHERIES

THE mortality of oysters in Louisiana waters in 1932–33, coincident with the development of oil wells in the coastal areas of the state, brought up again a question as to the possible effect of oil on oysters and marine life. The writers set out to investigate exactly what bearing oil well pollution might have on oysters; to this end funds were allotted in 1934 by the Civil Works Administration, which sufficed to carry out a hydrographic survey of the conditions in Terrebonne and Timbalier Bays, La., and laboratory experiments at Beaufort, N. C., Woods Hole, Mass., and Washington, D. C. As a result of this work much has been learned about the possible effect of oil pollution on oysters and the conditions in the Louisiana oyster beds. The report comprising the results of the investigations has been completed and will be published by the Bureau of Fisheries in a short time.

The questions confronting the investigators were two—whether the unusual mortality which occurred in Louisiana in 1932–33 was attributable to the discharge of oil and bleed water, and how further development of the oil resources of the coastal section would affect the cultivation of oysters.

An important difficulty in answering such questions is that the marine biologist is called in to investigate the cause or causes of mortality several weeks or months after death has occurred and when the conditions responsible may have been changed or removed. The present report fails to give a definite answer to the cause of the heavy mortality of 1932–33 in Louisiana, but does throw some light on an even more important matter, namely, the possible dangers of oil pollution to oysters. Because of the limitation of funds, the authors concentrated their attention on experimental studies of the effects of oil on the behavior of oysters and the growth of diatoms which constitute the principal part of the oyster diet.

Preliminary investigations, carried out by Prytherch in 1933, failed to reveal the existence of a direct correlation between the intensity of mortality and the distance between the affected oil bottoms and oil wells. A number of oysters, barnacles and green algae were found growing on the piling of oil wells, and no unusual mortality was observed among other organisms. The presence of small numbers of oysters on piling of oil wells was also observed in 1934 by Galtsoff and Smith. Examination of oysters and plankton showed that apparently there was no interference with the development of gonads, spawning and setting of the larvae. The diseased condition of oysters was evidenced, however, by the loss of muscular tonus and the failure of the adductor muscle to maintain closure of the shell. It is known that if such a condition continues for a long time it results in a stunted growth and abnormal shape of the shell. No unusual changes in the salinity of water and other hydrographic conditions, which might account for a great mortality, were disclosed by these observations.

The oyster enemies, the borer, the boring clam and the boring sponge, are rather abundant in Louisiana waters. Many dead oysters examined in 1933

showed heavy perforations caused by the boring clam and sponge, but, on the other hand, in one place which was examined, 95 per cent. of dead shells were not infested by these pests. Oyster growers have not noticed an unusual increase in abundance of oyster enemies, and no evidence has been obtained which would indicate that such an outburst occurred at the time of the mortality in the winter of 1932–33. It is significant that in 1933 the mortality affected chiefly the larger and older oysters of marketable size and in several instances was especially severe among the recently transplanted oysters. Undoubtedly, the practice of overcrowding the beds by planting from 700 to 900 barrels of oysters per acre may be one of the contributing factors which aggravates the situation and, in case of adverse environmental conditions or the poor condition of the oysters, may materially increase their mortality.

A more detailed survey of the oyster bottoms, made by R. O. Smith in 1934, failed to assign the mortality to any known disturbance of the natural conditions on oyster beds, as, for instance, temperature, salinity, current and invasion of enemies. It has been noticed that, in general, mortality has been higher on soft, muddy bottoms than on hard ground. At the time this survey was carried on, pollution was noticeable at the mouth of Bayou Grey, where the surface of the water was covered with oil for a distance of three miles below the wells and there was some mortality on the oyster beds of this section. All shells were covered with a brownish black coating of tarry consistency and the meats were unpalatable because of the strong oily flavor. Considerable quantities of oil were held by mud, and oily patches appeared on the surface when the bottom was stirred. Light films of oil were observed also in the vicinity of the Lake Barre wells. In 1934 oysters on many beds throughout the region did not become fat until February or March, which points to a possible scarcity of food or to a disturbance in the functioning of the organs of feeding.

The shallowness of the water throughout the oyster-producing region in Louisiana must be regarded as a factor which tends to magnify the action of any polluting substance. Due to stirring by wind the water carries much suspended matter which may absorb the pollutant, transport it over wide areas and deposit it on the bottoms far from the source of pollution. Observations in the polluted areas show that on account of the absorption by suspended clay particles, oil quickly disappears from the surface and, after being deposited on the bottom, remains there for a long time.

No information was obtained by the two surveys upon which to base an opinion as to the direct cause of mortality, but ample experimental evidence has been accumulated to show that the presence of crude oil in water produces conditions inimical to oysters.

The first series of experiments, designed to determine whether oysters could be killed by the presence of oil in the water or by direct contact with oil, gave negative results. Unfortunately, because of the circumstances over which the investigators had no control, these experiments were carried out not in Louisiana, but in a different environment at Beaufort, and uncultivated oysters taken from local oyster reefs were used. Samples of crude oil collected by the State Conservation Department from Louisiana oil wells were shipped to Beaufort and used throughout the experiments. It is quite possible that the results might have been different had Louisiana oysters been used. In a series of experiments, lasting from two to three months, the mortality of oysters kept in running sea water under a surface layer

of oil and those kept in sea water that passed through oil was no greater than that in the controls.

In another set of laboratory experiments no higher mortality than that in controls was observed among the oysters which, over a period of 6 to 8 weeks, were immersed at regular intervals in oil. In some of the experiments the mortality among the controls was as high as 50 per cent., indicating unfavorable laboratory conditions under which the animals were kept. It is possible that these conditions beclouded the effect of oil on oysters.

The fact that oysters survived the treatment with oil does not indicate that they were not affected by it. Analyses made by Galtsoff show a slight decrease in glycogen content of oysters kept in the laboratory in the oil-polluted water. The result may be due either to the disturbance in the functioning of the feeding apparatus of the organism or to the decreased supply of food.

A regular operation of the muscular mechanism involved in closing and opening of the shell is prerequisite to the normal feeding of the oyster. Two sets of experiments carried out by Prytherch in 1933 and Galtsoff and Smith in 1934, gave identical results, showing that the presence of oil has no effect on the mechanism of the adductor muscle.

In the first set of experiments, continuous kymograph records were obtained of five oysters, which were kept under observation for three months. The average number of hours per day the oysters were open was 11.2 for the controls and varied between 10.0 and 13.6 for the experimental oysters. In the second set of experiments, six control oysters, kept under observation from four to fourteen days, were open on the average of 10.5 hours daily, whereas the average figure for ten experimental oysters, kept under observation from four to eight days, was 9.6 hours. In both cases the difference is insignificant.

Although the presence of oil in the sea water does not reduce the number of hours the oyster keeps its shell open, and therefore the duration of feeding of the mollusk is not decreased, the rate of feeding is early affected by the presence of polluting substance. As the feeding of the oyster is primarily dependent upon the amount of water passed through the gills, the rate of pumping of water can be used as a measure of the rate of feeding. The results of the experiments show that crude oil contains substances soluble in the sea water which produce anesthetic effects on the ciliated epithelium of the gills. The inhibiting action is not due to the mineral salts that may be leached out in preparing the water-soluble fraction of the sample of oil by shaking it with sea water. It is apparent that certain organic compounds of oil are slightly soluble in sea water. This conclusion can be drawn from the observations that after twenty-eight washings with water, the sample of oil did not lose its toxic property and yielded an extract, the anesthetic potency of which was equal to those obtained with the first washings. The inhibiting effect of the water-soluble fraction is proportional to its concentration. From a large number of experiments the inference can be drawn that a concentration between 20 and 30 per cent. of the soluble fraction will, on the average, reduce the rate of feeding of the oyster to one half of its normal value.

Under the conditions of the experiments, the recovery of the ciliary motion following the removal of the oil extract was almost complete. Inasmuch as the experimental oysters were kept in the extract only for a limited period of time, the result of the prolonged exposure remains to be determined. There was no indication in the present experiments of an increased tolerance in oysters due to repeated treatment.

There was a large variation in the per-

centage of depression caused by a given concentration of the soluble fraction on individual oysters. Two explanations suggest themselves. First, there is a possibility that in spite of the precautions taken in preparing the soluble fraction, the toxicities of individual samples were different. Second, the oysters used in the experiments may have different sensitivity and tolerance. The second explanation seems to be more plausible, for the wild oysters used in the experiments at Beaufort, coming from exposed flats, greatly varied in appearance, glycogen content and other characteristics.

From a large number of experiments with the water-soluble fraction the inference seems to be inevitable that crude oil discharged in the sea, regardless of whether it floats on the surface or, having been absorbed by mud particles and deposited on the bottom, continuously yields water-soluble substances which narcotize the ciliated epithelium of the gills, reducing the rate of pumping of water and therefore materially decreasing the amount of food obtained by the organism. This should lead to gradual starvation and weakening of the organism. The chemical nature of the substances and their concentration in the oil-polluted areas remains to be determined by future investigations.

The effect of brine or so-called "bleed water," which accompanies oil discharged by the wells and is usually dumped into the sea, has been studied by using the same technique as was employed in the experiments with oil. It has been found that bleed waters of Lake Barre and Lake Pelto do not affect the muscular mechanism of the oyster in relatively high concentrations, provided the quantity present does not increase the salinity beyond the limits of tolerance. A 10 per cent. concentration of bleed water may exert a stimulating effect on the ciliated epithelium, at least in some of the individuals. The depressing effect occurs at the concentration of 20 per cent. and higher. A 33 per cent. solution reduces the rate of pumping of water by the gills to 32.6 per cent. of its normal rate. The percentages of brine which cause this or greater depression are beyond any possibility of occurrence in nature.

Experiments were set up to throw light on the possible effect of oil and bleed water on the production of the food of the oyster. It has been assumed that the results of the laboratory experiments with the diatom, Nitzschia, which occurs in the normal habitat of the oyster, and constitutes an important element in its diet are applicable to other species of diatoms. It has been found that the presence of a heavy layer of oil on the surface of culture flasks inhibits the growth of Nitzschia when oil remains on the surface for a week or longer. The soluble fraction of oil exerts a retarding effect on the growth of Nitzschia in concentrations of 25 per cent. and higher and when the extract is permitted to act over a considerable period of time. Low concentrations may have a slight stimulating effect. In many instances the addition of the oil extract stimulated the growth of bacteria, small numbers of which were always present in cultures, and caused the death of diatoms.

Water-soluble substances, obtained by dialysis through a collodion membrane, also exerted a retarding effect on Nitzschia, both in natural sea water and in Miquel solution.

Bleed water retards the growth of Nitzschia, the inhibiting effect being pronounced in concentrations of 10 per cent. and higher. The retardation of growth is directly proportional to the concentration.

The experimental evidence presented in the report shows that the discharge of oil into the sea produces profound changes in the normal environment of the oyster. The substances which gradually dissolve from oil in the sea water ir-

ritate the delicate ciliated mechanism. In a very dilute solution they may act as stimulants, but in higher concentrations they inhibit the activities of the ciliated epithelium and may bring about complete stoppage of the current of water through the gills. The same substances which reduce the rate of feeding of the organism affect its food supply by retarding the rate of propagation of diatoms. Obviously the presence of oil creates adverse conditions.

In the light of the present investigation, it is easy to conceive that, when the constitution of the organism is weakened by unfavorable meteorological conditions, natural changes in the environment or attacks of enemies, the pollution of water with oil may become a deciding factor which may cause irreparable injury, resulting in death. It is obvious that from the point of view of conservation, the natural resources of the sea must be protected from this danger.

PROTECTING CHILDREN FROM DEPRESSION DISTURBANCES

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SIX million children are already scarred in the economic struggle. The newborns are feeble; the infants are still strong; the children are stunted; the adolescents more sophisticated. An appraisement of under-privileged children reveals retrograde growth and development, resourceless emotional and social precocity, unadjusted personalities. The greater the toll of unhappy children the greater the incongruity of the coming generation. America's young men and women of to-morrow will thus become as ravid as those of Europe to-day—restless, rebellious, revolutionary. Physical deprivation at one age leads to mental distortion at another; the one is irreparable, the other insolvent.

What are the beginnings of child decadence in this country have reached extreme proportions in Europe. There it started slowly but cumulatively at the onset of the war when children were provided with inadequate food, little medical care and less security. But the actual deprivation that children suffered was no more deleterious than the indirect effects of world war activities. For example, the wild exportation of dairy products from Denmark deprived children of vitamin A, blinding hundreds with the disease xerophthalmia. The dearth of milk in Belgium and Germany deformed thousands with severe rickets. Lack of wheat gave them beriberi; the stinting of meat anemia. And the food rations for children in Central Europe produced such degrees of undernutrition that led to wide-spread childhood tuberculosis.

The by-products of these ailments were destructive of the personalities of Europe's children. It took long for the effects of these hardships to be recorded in their physical and mental conditions. The deformities diminished physical efficiency, curbed maturation, weakened personalities. Infections permeated the vital tissues, distorted their functions, sapped their stamina. Insecurity stifled emotions, strained nerves and unbalanced minds. The Europe of to-day thus reflects deprivation with cumulative mental and physical ill-being. What has happened in lands of economic difficulty is not inevitable in this country. The *modus operandi* of human beings is alike

throughout the world, although the course may appear different. Because America is in its material ascendancy the effects of the depression are less blatant.

The birth rate has shown its characteristic increase during troublesome years. Births are prolific among the poor and even more so among the "depression poor." Certainly an increase in the size of a destitute family is no stimulus for the head of the household to become a more competent provider. A generation ago large families dwindled to a meager few grown-ups after disease and pestilence destroyed much of their progeny. Such does not maintain to-day, for the chances of survival are all with the young, provided they are properly maintained and medically supervised. The burden of the underprivileged large family becomes that of the state and nation. Apparently that stratum of society which can well afford to maintain large families controls conception. Even churches of many denominations advocate certain methods for regulating the size of families and present the information to those in quest thereof. But the parents who are most in need of this knowledge rarely seek it. A worthy service on the part of governmental agencies would be to inform members of large underprivileged families ways of maintaining them without undue propagation.

The newborns of the "depression poor" are more feeble than their former progeny. The weights are less, although the lengths tend to be the same. The babies are less vigorous, although physically they appear well built. They develop more disturbances incident to the initial adjustment. The reaction of newborns to the conditions of their new environment is an index of the vitality acquired in utero. Those too feeble to cope with the situation after birth succumb promptly because they have probably been exhaustion products. There is a popular misconception that these neonatal deaths are due to developmental anomalies. As a matter of fact only 2 per cent. of newborns lost at birth are the result of congenital malformations. Two thirds of the deaths are the result of disturbances associated with the nature of the delivery and the other third are the consequence of infections acquired before, during or after delivery. Obstetrical technique is being perfected in spite of depression, but even superior medical care of newborns can not save lives of enfeebled stock. The only means of diminishing the loss of the newborn population is to provide for their supervision prenatally. Mere provision of emergency care during the preconfinement period is a hazard to both mother and offspring. The character of the delivery is determined by the supervised course of the entire period of pregnancy. Therein lies the key to most of the preventable maternal difficulties and deaths. The greatest disturbances befall the child long before it is born. Many of these are preventable by proper medical care of the expectant mother from the first weeks of pregnancy. The provision of more health stations, obstetrical clinics and maternity centers to coordinate their supervision with the economic status of the family will improve and protect the progeny.

Infants have suffered least from the effects of the depression. Feeding has become so simple and the care so standard that babies thrived in spite of adverse home conditions. Nevertheless, a comparison of infants from various sectors of society shows less favorable body build for the underprivileged than for the well-to-do. Indeed, the difference in the vitality between these two groups is sufficiently great to take heed. It suggests that the factors responsible for the superior rearing of infants are worthy not only of maintenance but of enhancement. Governmental agencies should

therefore provide more health stations, well baby clinics, health centers in the districts that have suffered most from economic stress. There are apparently enough agencies qualified in infant welfare, enough public health nurses at hand and enough physicians without personal practice to serve in this cause. All are available and yet have not been marshalled for the infant population. The cost of such centers is less of an item than the political resistance to community health organizations. The greatest conflict is between private practice and so-called socialized medicine. Provision of infant welfare stations is an extension of a service well under way and does not conflict materially with desirable private practice of physicians.

School children have suffered tangibly from the depression. Growth and development have been definitely diminished compared with their previous tempo of progress. Contrasting are the physical demarcations in the children of the well-to-do, the "new poor" and the chronic poor families. The children of the first group are accelerated two to three years, while those of the other two groups are manifestly retarded. The children of those families who were hardest hit by the depression suffered most physically. The young apparently reflect in ill health any sudden change in lowering their standards of living.

The first manifestations of deprivation constitute malnutrition. It represents varied symptoms and physical signs peculiar to each child. Many are the possible disturbances consequent upon malnutrition, for at least forty nutrients are necessary for daily maintenance and growth. If any one of these are inadequate or deficient, nutritional deficiencies develop progressively. The deprivation becomes cumulative and the children really suffer from an aggregate of several deficiency diseases. Not only is growth affected but the physical efficiency of all tissues impaired. Most malnourished children are maintained on essentially carbohydrate feedings of limited food value. Their energy requirement is usually fulfilled by an abundance of rice, macaroni and beans with consequent protein, mineral and vitamin starvation. The undernourished young bodies are media par excellence for the dissemination of infection. And unhygienic overcrowded quarters, housing families that are doubling up in homes, become veritable incubators of infections and cross-infection. They gradually devitalize malnourished children, retard their development and blight their youth.

Contrary to current notion growth does not cease during semi-starvation. Certain tissues appear able to appropriate nutrients and grow at the expense of other organs of the body. There is such a harmonious equilibrium between tissues that none wanes without the others responding to their cause. Most of the required nutrients of the body are distributed in depots ready for release on tissue demand. The body begins to live from its inner self rather than from the external environment. These self-consuming mechanisms have their limitations. The usual change in body build during periods of undernutrition is abnormal elongation. Persistent skeletal growth results in emaciation caused by atrophy of the softer tissues. In some children there is also an enlargement of the head and a disproportion in the growth of the extremities, depending upon the age and type of malnutrition. Distorted growth is more prevalent during the cycles of rapid growth—infancy, the period of second dentition and pubescence. During the interim periods of body broadening there is less disproportion in body build from malnutrition.

What is the possibility of recovery from prolonged malnutrition? The child's body is a very labile mechanism with remarkable powers of recovery, provided proper nutrition is afforded before extreme stages of malnutrition are

reached. The younger the child the less complete the recovery because of accelerated growth during the first years of life. Infants who lose more than 30 per cent. of their weight have their tissues so inalterably affected in structure and function that they usually succumb. Older children have greater powers of resisting such tissue changes. In the Russian famine children recovered from extreme emaciation but were markedly thwarted in body build and in physical functioning. No generalizations are possible with regard to the amount and degree of dwarfing from undernutrition because of the many factors involved in growth.

Whatever the cause of malnutrition, it is ever an index of extreme maladjustment, physical, nutritional or emotional. The lean child does not necessarily exemplify undernutrition because average body measurements do not indicate nutritional status. The malnourished child fails to gain in weight, has flabby musculature, strained nerves, poor digestion, lowered resistance. The condition is alleviated by a body-building dietary to effect healthy gains in weight. It is not sufficient to overload the body with fat-forming foods. All forty nutrients are indispensable for well-being. The diet should furnish the largest number of tolerated calories in their most digestible forms. Diversification of food is not necessary, for no disturbances are ever caused by monotony of diet.

Food money for the underprivileged should be distributed in fifths—one fifth for milk and its products, one fifth for vegetables and fruits, one fifth for meat, fish and fowl, one fifth for breads, cereals and starchy foods and one fifth for the foods particularly cherished by the family. At least one pint of milk, fresh, evaporated or dried, is necessary for a child. Each form of milk provides the same content of nutrients. The choice should therefore depend on the cost. Similarly, the cost of vegetables and fruits is no indication of their nutrient value. The soil is not in league with man's palate. The less expensive produce furnishes the necessary minerals and vitamins, in tomatoes, potatoes, cabbage, yellow turnips, bananas, prunes, obtained raw, preserved or canned. Every housewife knows that the less preferred cuts of meat are least expensive. Some of the viscera are equivalent to liver in superior protein and anti-anemic factor. Such organs as lung, kidney, spleen and tripe are economical because of infrequent demand. Whole-grain breads and cereals are preferable and may be obtained at half cost when bought one day old. The nutritional value is the same and the digestive greater for children. Cod liver oil is a necessity for undernourished children. The highly advertised brands are biologically tested but expensive. Other fish oils are equally effective and more economical.

Relief for the depression poor maintains adults at the expense of children. Few parents, irrespective of intelligence, appreciate the food requirements for their children. And emergency feeding is given no consideration in the strain of family insecurity. No attempts have been made by governmental bureaus to allocate foods of choice for children. Certainly the disbursement of relief funds requires nutritional supervision of malnourished children. The dead hand still guides many an archaic organization impervious to progress. They take no precautions to safeguard the well-being of youth in distress. It may be well for the grown-ups gripped by baseless food prejudices to continue in their dietary abnormalities. Their habits are difficult to change. And those who make intelligent efforts to readapt themselves to newer knowledge merely rearrange their prejudices without actually changing their habits. The damage done to children under such primitive home surroundings is irreparable. There is an administrative and educational challenge

to the relief organizations at work to spare children from dietary prejudices and help build for them sounder physiques. Malnourished children require nutritional supervision at home and medical supervision at special clinics. Food deficiency alone is rarely the factor productive of extreme malnutrition. Medical care must be provided to eliminate focal infections, correct physical defects and regulate health habits apart from perfunctory arrangement of adequate dietaries.

Physical degradation of children has been associated with deep-seated disturbances. Intangible and devastating indirect effects of the depression are emotional and mental illness. They are the devastating consequences of family integration. The problems of the grown-ups become the anxieties of the young. Family relationships mould the personality traits and life attitudes of children only to distort them under economic stress. The home atmosphere is tense with concern about the family income. The children worry about diminished comfort, change of residence, loss of friends, lack of clothes, insufficient food, deprivation of delicacies. These are but few of the daytime difficulties that befall the child at home. Equally prevalent are the night problems. The crowding of several members of the family in the same room if not the same bed instills emotional immaturity, protracted dependence, irritability, masturbation. Thwarted physically and emotionally, the child's attitude towards life becomes distorted. He is rebellious, disagreeable and sullen. The nervousness is expressed in fears, physical complaints and anti-social activities.

The ever-present sense of insecurity troubles children of the new poor more than those of the chronic poor. The sudden change in the economic status of the family disequilibrates sensitive personalities, with consequent functional disorders. Mere physical examination reveals no organic disease. Physicians confronted with no physical basis for complaints shrug their shoulders with a feeling of despair with regard to alleviating such intangible disturbances. The province is in the realm of the child psychiatrist who has determined the relation between the psychogenic factors and physical dysfunctioning. The child makes an unconscious flight into disease from which he derives emotional gain. Expressed differently, home problems precipitate a body protest in the child. The physical disorder serves as an outlet for worry, disappointment and other difficulties. Few realize that a child takes his troubles as seriously as adults take theirs. The mental makeup of the child also has a psycho-pathology of its own. It is unraveled, not in terms of the irrelevant symptoms presented but rather in terms of the child in his entirety with attention to his constitutional, physical, mental, emotional and environmental peculiarities.

The more serious evidences of maladjustment are shyness, sensitiveness, lack of sociability, suspiciousness, resentfulness, fearfulness, cruelty and tendency to depression. Parents erroneously consider other types of negative behavior such as cheating, lying and stealing as more serious. Misbehavior calls for prompt interpretation of the child's difficulties. It is necessary to seek the motif underlying the behavior rather than to label it good or bad. The first approach in abating personality difficulties is to work with the child as much as possible. Physical deviations should be corrected to set up a level of well-being that is more desirable for successful adjustment, for behavior constitutes a set of overt functions so integrated in the total personality that smooth working depends upon positive health. Then comes the correction of faulty attitudes which the

child has formed with regard to his psychic disturbances in the depressed environment. Parents frequently use the term nervousness as an explanation of behavior difficulties. The term they consider harmless sets up strange ideas in the child interfering with simple appeal to his powers of reason. Once self-confidence is instilled the child will overcome his difficulty to the extent that he gradually becomes adjusted to the exactions of his environment.

But abnormal behavior is the consequence of strained inter-personal relationships. As it is ineffective to treat a complaint without considering it an integral part of the entire being, so is it impossible to deal with the child detached from his environment. The whole family is intimately linked with the child's difficulties. Their over-indulgence, over-ambition or indifference and carelessness breed behavior disorders. The child's educators must be educated by enlisting their cooperation intelligently, convincingly and concretely. Improvement is possible only with a modification of the environmental circumstances that have precipitated the strain and simultaneously effect a change in the parent's attitude towards the child. Underprivileged parents and children bear three kinds of trouble—those they had, those they have at present and those they expect to have. Even if all the material difficulties were adjusted to their immediate satisfaction the adults would still be brooding and the children would be in accord. It is therefore equally important in providing relief to teach parents to view life's ups and downs with equanimity, to try to maintain a calmer outlook on life if they are to instill any iota of happiness into their children. Unfortunates are never convinced that true happiness comes from their own mental attitude rather than from an environmental heaven.

But dealing with the child and his family may not yield satisfactory adjustment. Contact may be necessary with special communal agencies, schools, psychiatric institutions, child guidance clinics, welfare agencies. But the competent staffs of many of these organizations have been disbanded at the onset of the depression. Relief agencies created provide mere maintenance, the benefits of which are minimal to children. Undernutrition persists, behavior problems multiply, disease and defectiveness spread. This devastation can be halted by material provision reinforced by supervised educational measures. Innumerable are the trained health workers who can serve the nation in this cause. Certainly practical methods can be formulated to help difficult families in both mental and physical health. In that realm remedies are clear-cut, yet no effort is made to apply them. With a sick world, faltering business and wavering counsels, protective health measures can be conscripted.

EVIDENCE FOR AN EXPANDING UNIVERSE

By Dr. M. L. HUMASON

MOUNT WILSON OBSERVATORY, CARNEGIE INSTITUTION OF WASHINGTON

THE astronomer's instruments are many and varied. Most important of all is the telescope itself; in addition, there are numerous auxiliary instruments and attachments, spectrographs in many forms and the equipment of the instrument and optical shop and of the modern physical laboratory.

MEASURING MOTIONS OF DISTANT UNIVERSES

At the Mount Wilson Observatory of the Carnegie Institution is the 100-inch reflecting telescope, the largest in the world. The great light-gathering power of this instrument has made it possible to investigate numerous problems which, except for a costly expenditure of time, could not have been carried on with smaller instruments. One of these problems is the motion toward us or away from us of the distant universes of stars which lie outside our own system or galaxy and are called the extra-galactic nebulae.

The first velocity of an extra-galactic, or spiral nebula, the Great Nebula in Andromeda, was measured by V. M. Slipher, of the Lowell Observatory at Flagstaff, Arizona, in 1912. It was already known that the spectra of these nebulae are similar to the spectrum of the sun, but the faintness of the nebulae had prevented the measurement of their velocities, until Slipher succeeded in reducing the necessary exposure by devising a very efficient camera for use with his spectrograph.

To obtain a photograph from which a velocity can be measured the feeble light from the nebula must be separated into its component colors by a prism. The two strongest lines crossing the spectrum, H and K produced by calcium, are usually the objects measured. If these lines are shifted to the violet from their normal position, the nebula is approaching; if shifted to the red, it is receding.

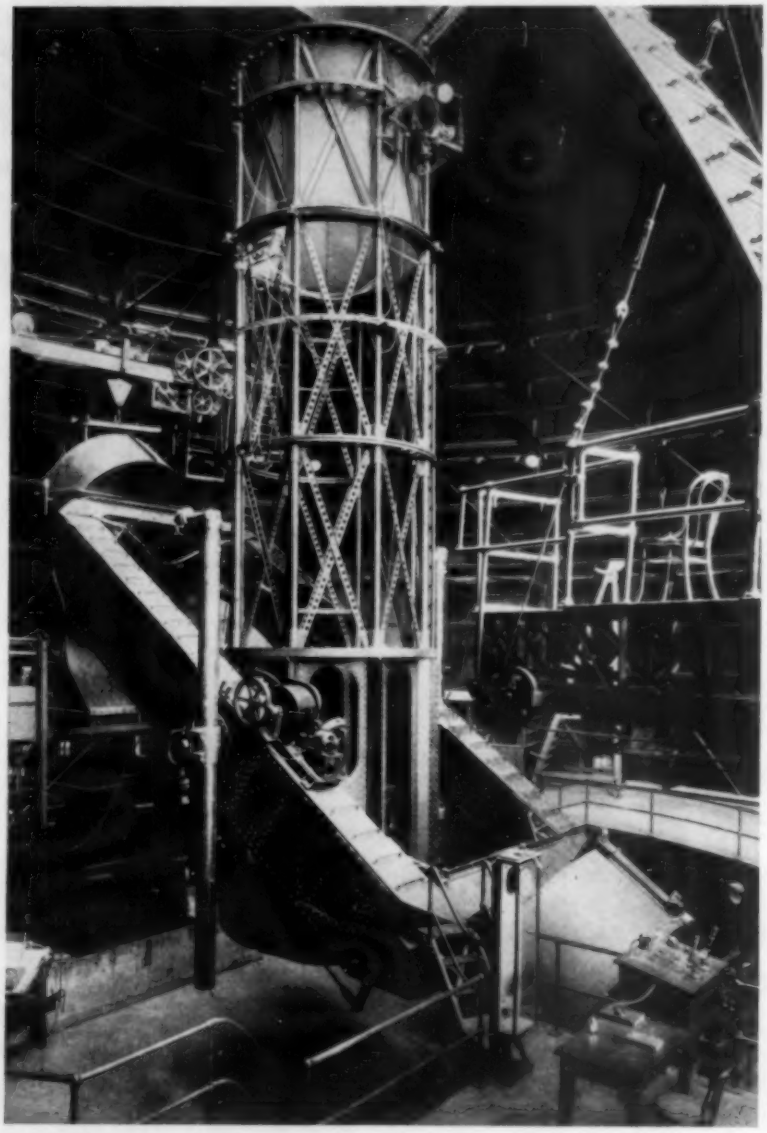
By 1925 the velocities of 45 nebulae had been measured, 40 of which were found to be receding into space with velocities ranging from only a few miles per second to as high as 1,100 miles per second, far higher than those of any other known astronomical bodies.

DETERMINING DISTANCE

In 1916, de Sitter, on the basis of relativity, had predicted that the spiral systems outside our own system should show receding motions which should be the greater, the greater the distance of the system. It was not then possible to test this predicted relation between distance and amount of motion because the distances of the spiral nebulae were not known.

The discovery of Cepheid variables in some of the nebulae by Dr. Edwin Hubble in 1923 removed this difficulty. The period during which the light of these variables changes tells how bright they are—their candle power; comparison of candle power with observed brightness gives the distance. Thus the Andromeda Nebula and Messier 33 were found to be at distances of about 870,000 light years, and hence must be systems similar in content and size to our own system.

Confirmation that these distances were essentially right was furnished by other individual stars that could be recognized in the nebulae, such as novae and the stars of very high luminosity. Continued study indicated that the nebulae themselves are all of the same general order of brightness and that differences in the total brightness of individual sys-



100-INCH REFLECTING TELESCOPE

THE EVIDENCE FOR AN EXPANDING UNIVERSE COLLECTED BY DR. HUBBLE AND MR. HUMASON WAS OBTAINED WITH THIS INSTRUMENT. VELOCITIES OF NEBULAE AT DISTANCES UP TO 250 MILLION LIGHT YEARS CAN BE MEASURED, WHILE DIRECT PHOTOGRAPHS RECORD STILL FAINTER NEBULAE AT DISTANCES AS GREAT AS 500 MILLION LIGHT YEARS.

tems is mainly an effect of distance. It thus gradually became clear that the brightness of a nebula is an excellent indication of its distance.

Relation Between Distance and Motion

The way was then opened for investigating the relation between distance and

motion, and Hubble was soon able to derive for the nebulae then observed a linear relationship between velocity and distance within a region of space whose boundaries were defined by the most distant nebulae in Slipher's list. These were five nebulae in the Virgo cluster which Hubble had placed at a distance of about 7 million light years.

The relation indicated that the velocities of nebulae increase at the rate of about 100 miles per second for every million light years of distance. The results also indicated that the velocity-distance relation, once established, could itself be used as a criterion of distance for all nebulae whose velocities were known.

The application of the new criterion to the nebulae in Slipher's list showed that in a general way the linear relation accounted fairly well for the observed velocities then available. The data were few, however, and further progress depended upon the extension of the observations to fainter and more distant nebulae, an investigation started at Mount Wilson in 1928, which would have been impossible except for the great optical power of the 100-inch telescope.

Nebulae occur as isolated objects, in groups and occasionally in great clusters, comprising 300 or more members, but when very large regions of space are compared, one region is very much like another. Hubble's relation between velocity and distance could be tested in two obvious and straightforward ways. First by observing numerous nebulae in many different clusters and, second, by observing nebulae fainter than those included in Slipher's list, on the assumption that such objects are at greater distances and therefore should have larger velocities.

Observations of nebulae in clusters afforded the more important test. Distances are rather accurately measured by the mean apparent brightness of the many members in each cluster, while the distances of isolated nebulae are reliable only in a statistical sense. In fact, the distances of clusters are the only great distances that can be assigned with confidence to individual objects in the sky. Moreover, the selection of the brightest members in clusters insures maximum distance for any given apparent brightness.

Definite Results Obtained

The first definite result was obtained in 1928 when members of a cluster in the constellation of Pegasus were found to be receding at an average rate of 2,400 miles per second, a value in good agreement with the estimated distance of the cluster, 23 million light years, and consistent with Hubble's conclusion that velocity increased with distance at the rate of 100 miles per second for every million light years of distance. Further, observations of several very faint isolated nebulae all gave very large velocities, thus again confirming the velocity-distance relation.

It was then planned to extend the range in distance to the observable limit of the 100-inch reflector by measuring the velocities of the brightest members in faint clusters of nebulae, to investigate the differences, if any, in the velocities of bright and faint nebulae in selected clusters, and, finally, to obtain a large sample collection of velocities of both bright and faint isolated nebulae.

Increasing Instrumental Power

The Mount Wilson observations used to test the relationship between velocity and distance had been obtained with the instrumental equipment then available at Mount Wilson. Although this equipment was powerful and efficient, it was necessary in order to obtain a single spectrogram for the measurement of the velocity of one of the fainter nebulae to extend the exposure over several nights. If still fainter nebulae were to be observed, it was clear that some further gain in instrumental power would be required.

This demand was supplied by a special objective for the camera of the spectrograph, designed by Dr. W. B. Rayton, of the Bausch and Lomb Optical Company, which led to a reduction of the exposure time to about one eighth that previously necessary.

Since 1929 when the Rayton lens was constructed the velocities of many faint isolated nebulae have been measured and, still more important, the observations of clusters of nebulae have been extended to include extremely remote objects. The list of clusters now observed is as follows:

Cluster	Distance in millions of light years	Velocity in miles per second
Virgo	7	750
Pegasus	23½	2,400
Pisces	24	2,900
Cancer	29	3,000
Perseus	36	3,200
Coma Berenices	45	4,700
Ursa Major No. 1	84	9,500
Leo	105	12,000
Gemini	114	15,000
Corona Borealis	120	13,000
Boötes	230	24,400
Ursa Major No. 2	240	26,000

Recession Velocities

At present the velocities of 189 extragalactic nebulae are known, of which 146 have been obtained at Mount Wilson since 1928. The observations cover a range in distance which is thirty-five times that available when Hubble first formulated the velocity-distance relation and indicate that out to the second Ursa Major cluster, at a distance of 240 million light years, the increase in velocity is still sensibly proportional to the increase in the distance. The recent observations change the rate of increase in velocity but little, from 100 to 110 miles per second for every million light years of distance. These observations extend to, or at least close to, the limit of present instrumental equipment and any serious revision of the relation must await the completion of a larger telescope.

In a single cluster, the Virgo cluster, over 30 velocities are now known. These velocities show an average range of 310 miles per second around a mean of about 750 miles per second, and in addition that the mean velocity of the faint nebulae is approximately the same as that of brighter nebulae in the cluster. Of the 189 velocities now known only 13 are velocities of approach, all of nearby nebulae for which the random part of the motion is larger than the part which depends upon the distance of the nebula.

Practically all the photographs were made with the 100-inch reflector. The photographic plate used is $\frac{1}{4} \times 1\frac{1}{2}$ inches. The length of the spectrum is slightly over 2/25 of an inch, and the exposure times range from 2 to 60 hours.

Nebulae in the two most distant clusters are too faint to be seen with the 100-inch reflector and were centered on the slit of the spectrograph by setting off the distance of the nebula from the nearest bright star as measured on a direct photograph of the field. Both of the objects measured in these two clusters are about 30,000 time fainter than the faintest stars seen with the naked eye.

Interpretation Still Controversial

Finally, it should be noted that the observational fact of the investigation is a close relationship between the brightness of a nebula and a shift of its spectral lines toward the red. Differences in brightness, in general, may confidently be interpreted as indicating differences in distances for the different nebulae, but the interpretation of the red-shifts as velocities of recession is still controversial.

On the other hand, if the interpretation of velocity-shifts as a motion of recession is abandoned, we find in the red-shifts a hitherto unrecognized phenomenon whose implications are unknown. The expanding universe of general relativity would still persist in theory, but the expansion would not then be indicated by the observations.

THE LATTIMORE HALL OF CHEMISTRY
WITH THE RUSH RHEES LIBRARY IN THE BACKGROUND

THE PROGRESS OF SCIENCE

THE ROCHESTER MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

For the second time in its history, Rochester, New York, welcomed the American Association for the Advancement of Science for a summer meeting. The first was held in the summer of 1892 and was the forty-first meeting of the association. The meeting just past was the ninety-eighth and was held in Rochester, from June 16 through June 18, following which the delegates journeyed to Ithaca to participate in the semi-centennial anniversary of Sigma Xi, held at Cornell University on June 19 and 20.

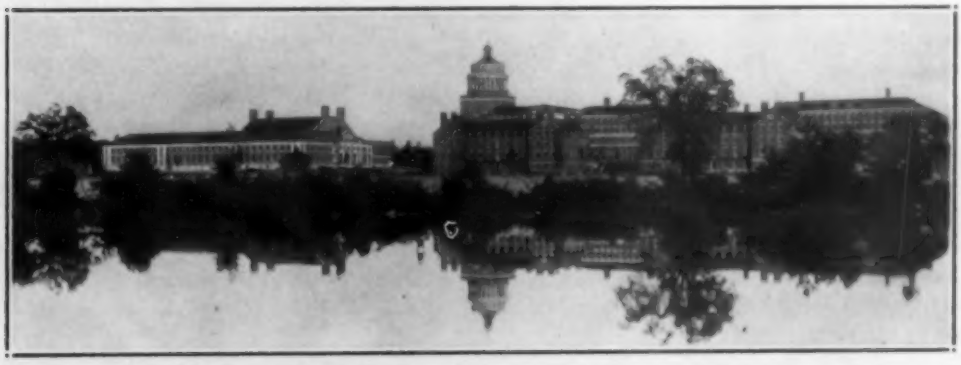
The city of Rochester, with a population of about 400,000, is located at the falls of the Genesee River, extending along its banks for about ten miles to its mouth on Lake Ontario. It is in many ways an ideal location for a summer meeting because of its normally mild summer climate and its location within easy reach of the Lake Ontario beaches, the famous Finger Lake region and other points of scenic interest, such as Niagara Falls and the Letchworth State Park.

Industrially the city of Rochester is of unique interest to scientists, being the home of the Eastman Kodak Company, the Bausch and Lomb Optical Company, Taylor Instrument Companies, the Ward Natural Science Museum, the Stromberg-Carlson Radio Company and other scientific centers. Excursions were arranged to the factories and research laboratories of most of these companies.

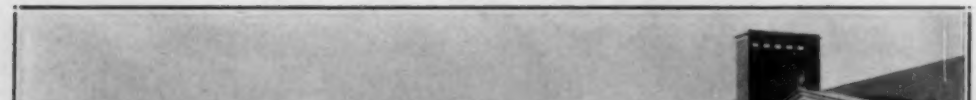
The University of Rochester, which was host to these meetings, is a non-denominational, privately endowed institution organized in 1850. As a result of generous gifts to the late George Eastman and of an extensive endowment campaign in 1920 the university has undertaken a considerable expansion of its activities since that time. It now consists of the College of Arts and Science, the Eastman School of Music and the School of Medicine and Dentistry.

The section meetings were held at the new River Campus of the College for Men and at the School of Medicine on adjoining grounds. The River Campus, which was first occupied in 1930, is located on a beautiful site overlooking the Genesee River and includes an exceptionally fine group of modern college buildings. Most of the science research laboratories are located on this campus.

The School of Medicine occupies a new group of buildings located within five minutes' walk of the River Campus. These buildings were erected in 1924 at the time the Medical School was organ-



RIVER CAMPUS FROM ACROSS THE GENESEE RIVER



EASTMAN QUADRANGLE OF THE RIVER CAMPUS

ized and contains some of the most modernly equipped medical research laboratories in the country. The Strong Memorial Hospital of the University of Rochester and the Rochester Municipal Hospital are included in this group.

The three evening meetings were held in the beautiful Eastman Theater. On Tuesday evening, June 16, Dr. C. E. K. Mees, director of research of the Eastman Kodak Company, spoke on "Color Photography." The Maiben lecture, held the following evening, was given by Dr. Charles Camsell, Deputy Minister of Mines of Canada. His subject was "A 4000-mile Flight over Northwestern Canada." This was followed by a reception given by President Alan Valentine and the trustees of the University of Rochester in the promenade of the Eastman School of Music. Dr. Carl Snyder, of the Federal Reserve Bank of New York, spoke on Thursday evening on "The Rôle of Capitalism in Civilization."

A symposium on "Flood Control" was one of the features of the meetings. The speakers were Dr. F. A. Silcox, chief of the National Forest Service, Dr. W. C. Lowdermilk, associate chief of the U. S. Soil Conservation Service, and Dr. Morris L. Cooke, administrator of the Rural Electrification Administration.

A symposium on "Social Security" attracted a good deal of attention. Another interesting event was the balloon ascension on Wednesday afternoon, June 17. Two high altitude radio-equipped balloons were released in order to continue lines of study inaugurated in the recent stratosphere flight and to record weather conditions.

On Thursday noon, June 18, at a complimentary luncheon at the Oak Hill Country Club to all delegates, the Bausch and Lomb Optical Company presented its 250,000th microscope, the culmination of sixty years of endeavor, to Dr. F. G. Novy, professor of bacteriology of the University of Michigan, in view of the fundamental significance of the researches he has made.

Thirty technical sessions were held, at which 200 papers were presented. These included special symposia on such subjects as weather forecasting, geophysics, biophysics, geology of New York State, dental caries, aerial photogrammetry and recent advances in medicine and bacteriology.

J. EDWARD HOFFMEISTER,
Chairman, Local Committee

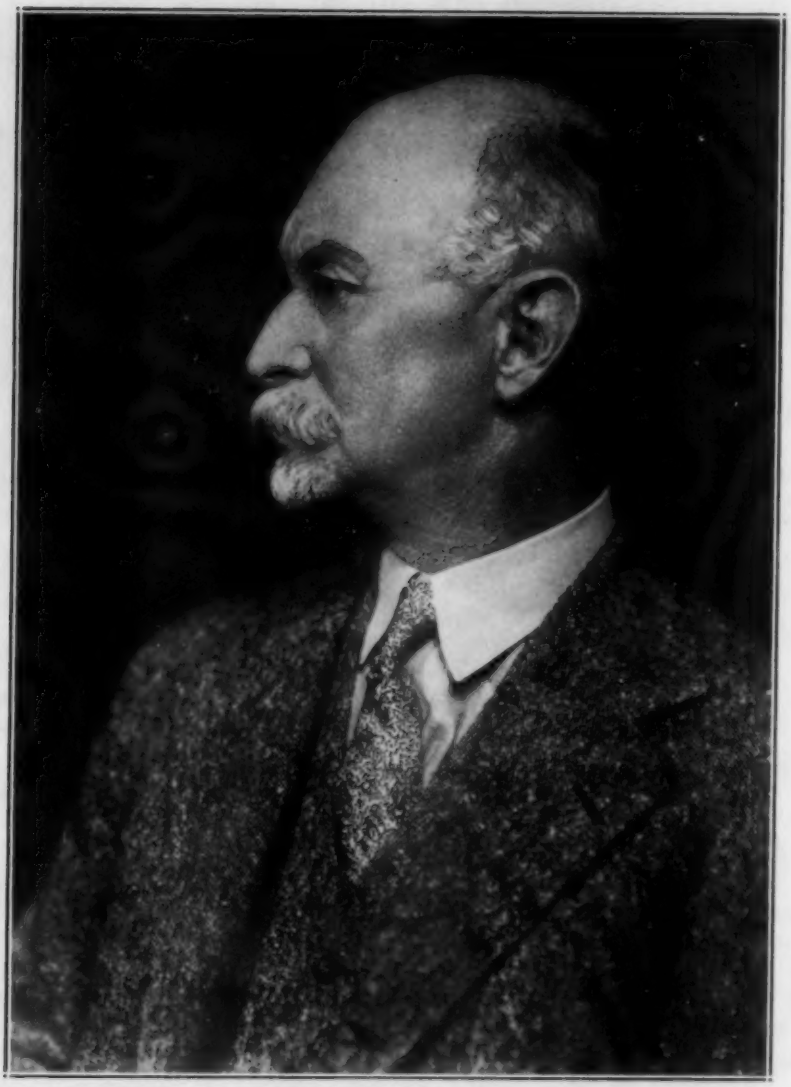
MEDALLISTS OF THE NATIONAL ACADEMY OF SCIENCES

THE practice of awarding medals is an old one. A medal is given to an individual either in recognition of distinguished service or in commemoration of an important event. Medals were first bestowed as rewards for military services rendered to King and country, the "Armada" medals of Queen Elizabeth being among the earliest of this type. During the next century medals continued to be awarded almost exclusively to men of the military forces; but gradually the importance of services, other than military, to the state were realized and medals were bestowed on civilians. The Royal Society awarded its first medal, the Copley, in 1731 to Stephen Gray; in 1753 this medal was awarded to Benjamin Franklin. The National Academy of Sciences awarded its first medal, the Henry Draper, in 1885 to S. P. Langley in recognition of his researches "in solar physics and especially in the domain of radiant energy." This medal had been made possible through a fund of six thousand dollars presented to the academy in 1883 by Mrs. Mary Anna Palmer Draper for the purpose of establishing a gold medal to be awarded to "any person in the United States of America or elsewhere who shall make an original investigation in astronomical physics, the results of which shall be made known to the public."

At the present time the National Academy of Sciences administers ten funds, the income from which is intended for use in connection with the award of medals in specified fields of science. Several of these funds provide honoraria in addition to the medals. Thus far the academy has awarded 102 medals in honor of scientists whose research work has contributed notably to advance of knowledge.

At the seventy-third meeting of the National Academy of Sciences, held this year from April 27 to 29 in Washington, two medals were presented: The Agassiz Medal for Oceanography, awarded to Dr. T. Wayland Vaughan, director of the Scripps Institution of Oceanography of the University of California, La Jolla, California, "in recognition of his investigations of corals, foraminifera and submarine deposits and for his leadership in developing oceanographic activities on the Pacific Coast of America"; the Public Welfare Medal of the Marcellus Hartley Fund, "awarded to Dr. F. F. Russell, formerly director of the International Health Division of the Rockefeller Foundation and at present lecturer in preventive medicine and hygiene and epidemiology at Harvard University, Cambridge, Masachusetts, in recognition of his work on the etiology of yellow fever and studies of epidemic areas."

Dr. Henry B. Bigelow, member of the Murray Trust Fund committee which recommended the award of the Agassiz Medal for Oceanography to Dr. Vaughan, referred in his presentation speech to the fact that "the oceanographer is constantly reminded that understanding of the margins of the oceans and of the parts of the earth's crust on which the latter rest is as integral a part of his science as is examination of the waters themselves, for these geologic features determine the extent, depths and circulatory systems of the oceans with all that this implies. Conversely, we can not hope to understand the geology of continents or of islands until we understand the structure and history of continental shelves, of ocean floors or of the corrugations of the latter. It is, therefore, eminently fitting that the academy should honor one who, commencing his career as a geologist, soon turned to the geologic history of shore lines and of the sediments of the seas—especially when we remember that the donor of the medal, Sir John Murray, was himself the most eminent student of oceanic deposits. We see Vaughan's genius and the part he has played in the progressive unfolding of submarine geol-



DR. T. WAYLAND VAUGHAN

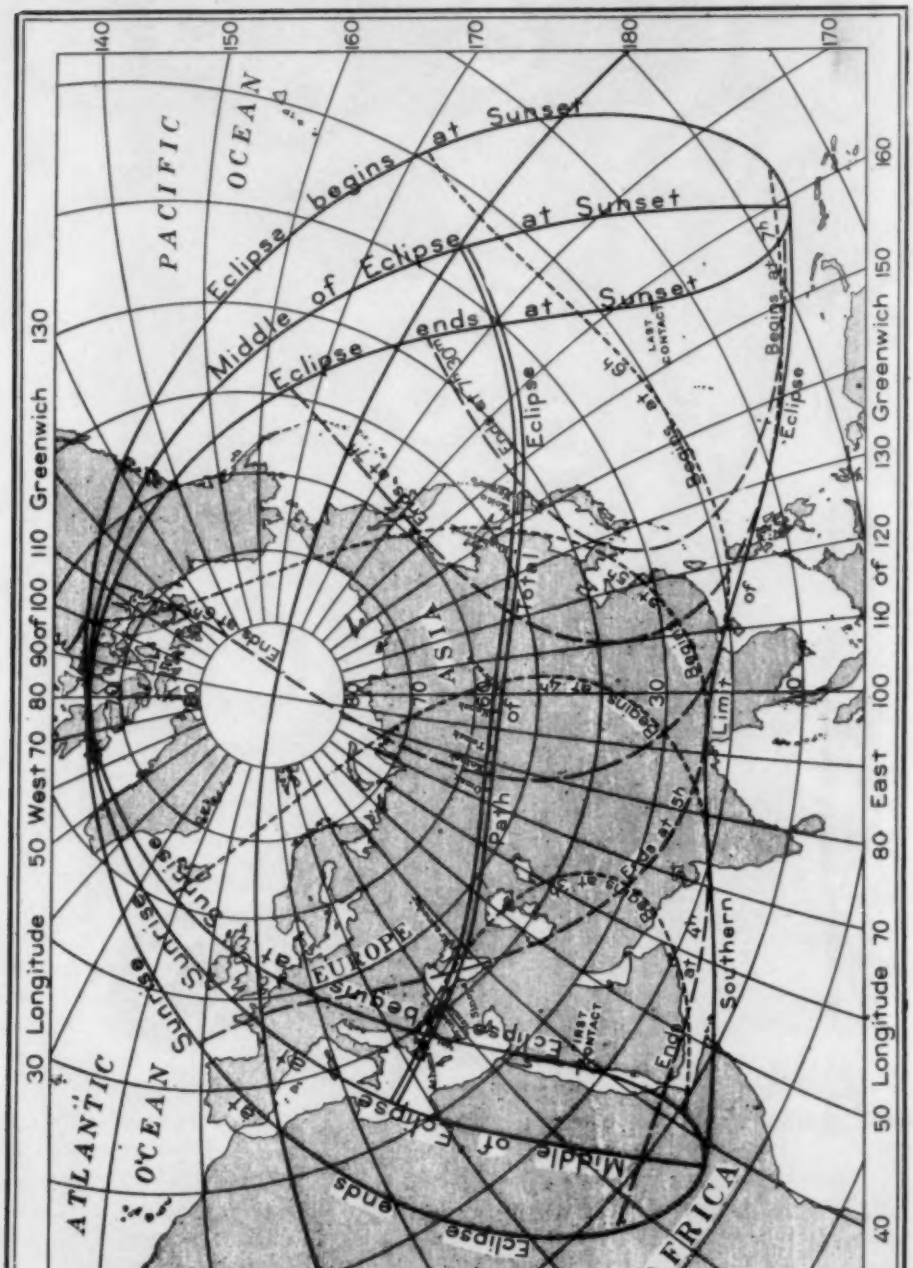
ogy in his studies of the corals and coral reefs of past ages, of the history of the islands of the West Indies and of the Floridian almost-island; of the organic skeletons that accumulated on the sea floor in past geologic ages, as exemplified especially by the fossil Foraminifera; leading, in order of evolution, to his examination of modern sediments, Atlantic and Pacific." Dr. Bigelow emphasized further the part played by Dr. Vaughan in building up the Scripps Institution and to its achievements during his directorship in adding to "knowledge of Pacific circulation in general, of California up-welling waters and their effects on organic fertility, of ocean dynamics, of the interrelation between sea temperatures and meteorologic phenomena."

In his presentation speech, Dr. Max Mason, member of the Marcellus Hartley Fund committee which recommended the

DR. F. F. RUSSELL

award of the Public Welfare Medal to Dr. Russell, remarked, by way of introduction, that "the curiosities which stimulate the development of the sciences are sometimes derived from abstract contemplation of the known facts and their cataloging concepts. These curiosities arise with compelling insistence, however, when a scientifically conceived attack on an important practical problem reveals the inadequacies of existing knowledge. The achievements of Frederick Fuller Russell are important examples of the successful application of science to human welfare and illustrate the advance of science through interplay of theory and practice." From 1920 to 1936 Dr. Russell was director of the International Health Division of the Rockefeller Foundation.

In the words of Dr. Mason, "Russell brought to the Foundation high abilities for administration as well as unusual aptitude and training in scientific medicine.



U. S. Naval Observatory

THE PATH OF THE JUNE ECLIPSE

THE HOURS OF BEGINNING AND ENDING ARE EXPRESSED IN GREENWICH CIVIL TIME

Under his direction the International Health Division continued its sympathetic and understanding cooperation with governments in building up public health organizations and in training public health personnel, and intensified the efforts of its own staff in disease control. To Russell disease control meant the study of disease in its own environment, by men of thorough scientific competence. This field work was backed by basic laboratory work at home and constant interplay between field and laboratory ensured the rapid application in the field of new laboratory findings, while the studies and experiences in the field stimulated new research at home. Only by insistence upon this unity of effort could such remarkable progress have been gained in the etiology and control of malaria and yellow fever as was accomplished by the staff during Russell's leadership. . . . Such is the nature of the work of Russell, the scientist and the administrator. Those of us who have counted him as a colleague and love him as a friend alone know the full measure of the man."

In his response, Dr. Russell commented on the cooperative aspects of the public health work and on the nature of the problems which were attacked under his direction. To quote his words: "I realize as you all do, that the medal is given me because I was the director of a group of workers, and that the honor is for the group and that on this occasion I merely represent it." His address ended in the same key: "Again Mr. President, I thank you for the honor and for this opportunity of speaking for my coworkers."

F. E. WRIGHT,
Home Secretary

ECLIPSE EXPEDITION TO THE U. S. S. R.

Two expeditions to observe the total eclipse of the sun on June 19 have been sent to Soviet Russia by the National Geographic Society in cooperation with Georgetown University and the National Bureau of Standards.

The National Geographic-Georgetown Expedition will be located near Kustanai, U. S. S. R., northeast of the Caspian Sea. Its leader is Dr. Paul A. McNally, director of the Georgetown College Observatory, Washington, D. C.

The program of this expedition includes spectroscopic analysis of the light of the sun's corona, direct photographs of the eclipse, both in black and white and in color, photometric measurements of the intensity of light at various stages of the eclipse and timing of the contacts of the sun and moon at the beginning and ending of the eclipse.[1]

The duration of totality in the vicinity of Kustanai will be 127 seconds. Meteorological data based upon observations during several years past and made available by the Government of the U. S. S. R. show a high probability of clear weather at the time of the eclipse in this region.

In addition to attempting direct color photographs of the eclipse the expedition will make a series of pictures with special filters sensitive to various wave-lengths of light. These pictures will be in black and white, but the degree of blackness on each plate will show the intensity of the particular color that registered predominantly on each particular plate. Then by comparison with a scale of intensity of black and white the proper shade of color for each picture can be determined and added. Superimposing all the

[1] Totality will occur at Kustanai at 8: 24: 56.8 A.M., June 19, in terms of World Standard Time. This corresponds to 11: 24: 56.8 P.M., June 18 Eastern Standard Time in the United States. Since clocks in Russia were set ahead permanently one hour in 1930 by Government order, the official time of totality, measured locally in Kustanai, will be 9: 24: 56.8. Totality will occur at Ak Bulak a little more than an hour earlier than at Kustanai.

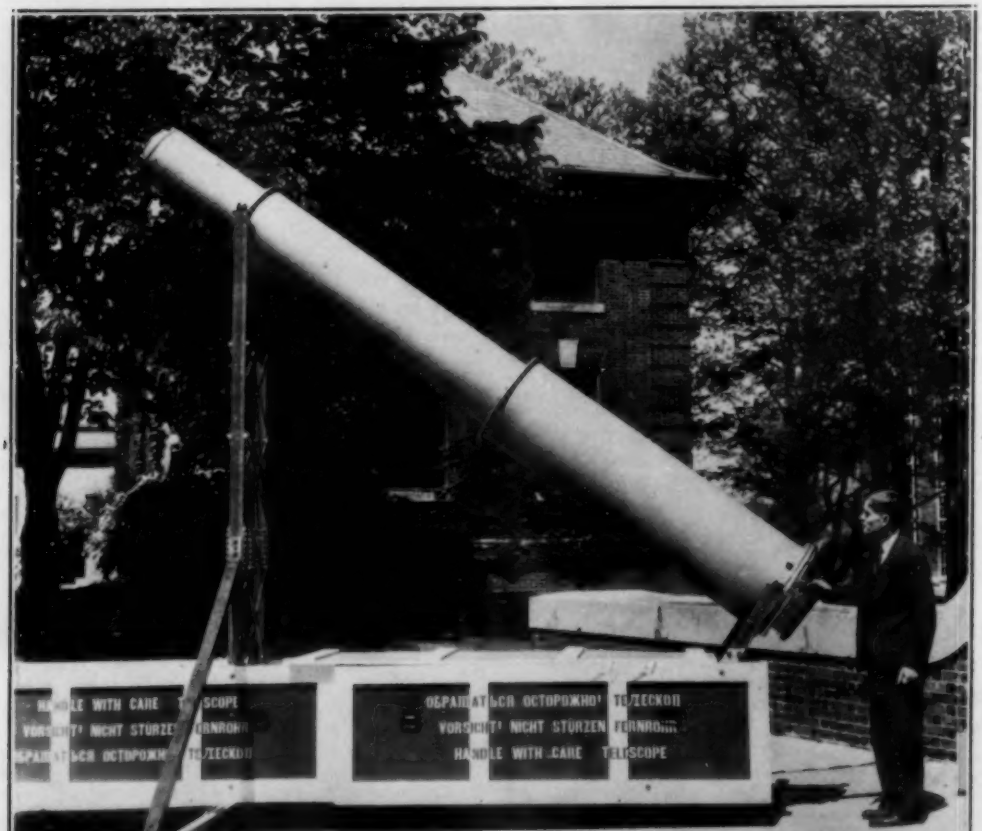
plates, each with a different color of the spectrum, should provide a synthetic picture of the eclipse in its actual colors. This method of capturing the colors of the eclipse never has been attempted previously.

In the direct photography of the eclipse a panatomic emulsion of extremely fine grain will be used for the first time in eclipse photography, making possible enlargement of the photographs approximately 500 times, a greater enlargement than previously has been attained in eclipse work.

The expedition also will use photographic emulsions new to eclipse photography for registering the "flash spectrum" which becomes visible just before the moon completely covers the face of the sun. With the new emulsions it is hoped to record invisible infra-red light of the flash spectrum up to wave-lengths of as much as 12,000 Angstrom units, several thousand Angstroms farther out toward the infra-red than has previously been accomplished in recording the flash spectrum.

The timing of the eclipse will represent a special investigation on behalf of the United States Naval Observatory, and the observatory will broadcast special radio time signals with special intensity as an aid to this program.

The corona, always one of the most



National Geographic Society

DR. IRVINE C. GARDNER
WITH THE 14-FOOT CAMERA

National Geographic Society

DR. PAUL A. McNALLY
WITH THE TELESCOPE AND OTHER EQUIPMENT

interesting features of an eclipse of the sun, is expected to be roughly square in shape during this year's eclipse instead of extending outward in long streamers, as was the case in the eclipse of 1932. The shape of the corona varies with the progress of the 11-year sun-spot cycle, and the long streamers appear when the spots are approaching a minimum, whereas this year the spots are on the increase.

The National Geographic-Georgetown Expedition will have more than four tons of equipment. Its personnel, in addition to Dr. McNally, includes: Emeran J. Kolkmeyer, Thomas J. Smith and Carl H. Spriegel, of Georgetown University, and William Robert Moore, of the National Geographic Society.

The National Geographic-Bureau of Standards Expedition will be in charge of Dr. Irvine C. Gardner, of the Bureau of Standards, assisted by Mrs. Gardner, who is, herself, a qualified scientist. Their headquarters will be at Ak Bulak, U. S. S. R., about 370 miles southwest of Kustanai.

The Gardners will photograph the sun's corona by means of a 14-foot camera equipped with a newly designed astrographic lens, and designed to make photographs both in black and white and in color. The camera is mounted on a rigid demountable frame consisting in part of the cases in which it was shipped. Construction of the camera and its mounting as a single rigid unit has enabled the focusing and other adjustments to be made before leaving the United States, greatly reducing the time required for preparation in the field.

The new lens greatly reduces the necessary focal length and increases the speed of the photography. The lens will provide an image of the sun two inches in diameter on the photographic negatives, which will make possible enlargement sufficient to bring out considerable detail.

The photographs taken with this camera also will be used to measure the brightness of the corona at various distances from the sun. The intensity of black and white registered on the photographic plates when compared with a scale of various degrees of black and white will indicate the intensities of light which correspond to the degrees of the scale.

Ak Bulak, where Dr. and Mrs. Gardner will be stationed, also will be the headquarters of the joint expedition of Harvard University and the Massachusetts Institute of Technology.

M. K.

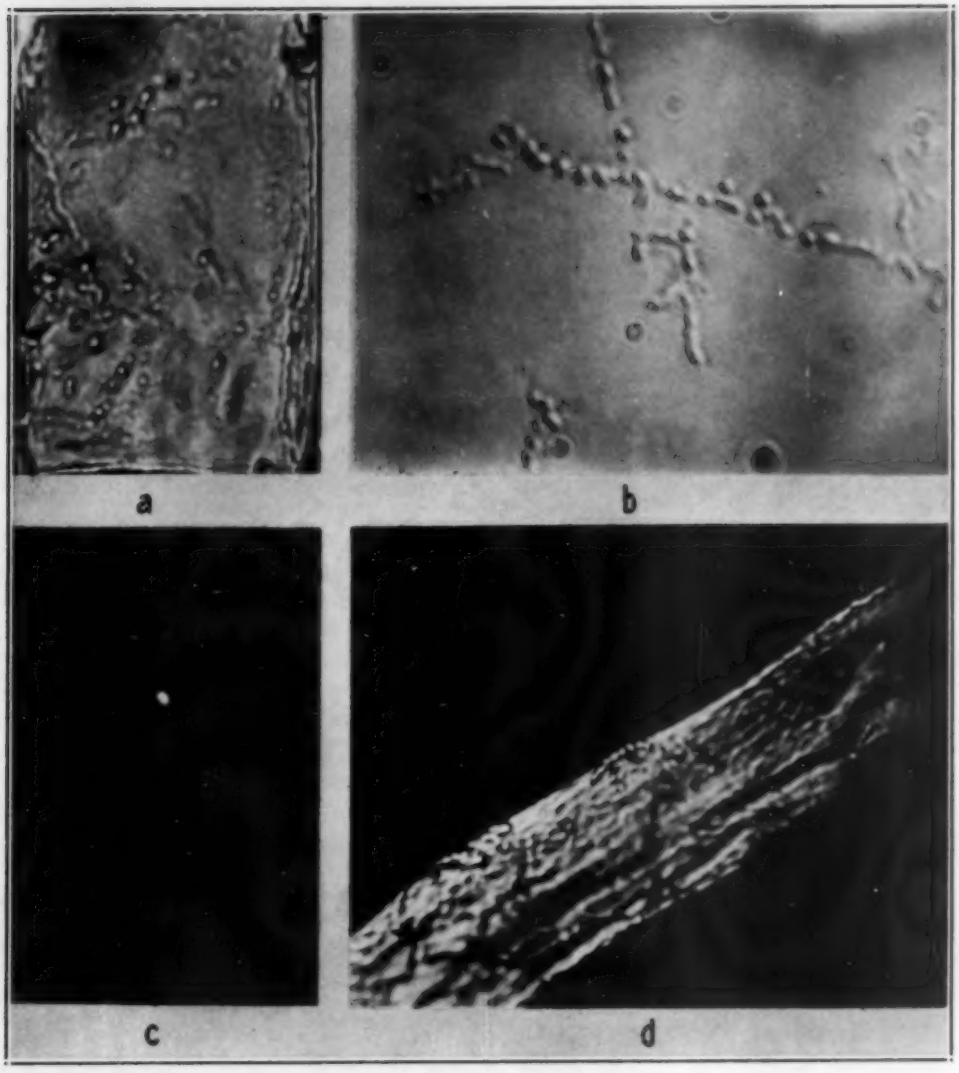
THE STRUCTURE OF "CELLULOSE"

THE important fact that the tissues of plants and animals are developed through the division, differentiation and enlargement of diminutive unit structures named "cells" is one of the major contributions of biological research of the past century. Before 1850 many of the structural variations of the cells themselves had been observed with the microscope and accurately described. The boundary of the animal cell was found, ordinarily, to be a thin, delicate membrane, while that of the plant cell was usually conspicuous, often quite rigid, and was referred to as the "cell wall."

The presence of crystalline material in this cell wall was quickly recognized by its appearance in polarized light. Its swelling behavior in water indicated a physical rather than a chemical change. A "micellar theory" based upon the idea that the wall was made up of submicroscopic crystalline particles (micellae) which were pushed apart by but did not react with the water was therefore elaborated. Subsequent workers have found that this crystalline material in the wall is a compound of carbon, hydrogen and oxygen. It is produced exclusively through the activity of the living protoplasm of the plant cell and has been named "cellulose."

Botanists have been interested in the structure and chemical nature of the cellulose membrane because all outside influences first encounter this wall and may change or be changed by it before reaching the interior of the cell. These reactions have been difficult to evaluate because of the supposed invisibility of the fine structure of the wall. Chemists have followed the behavior of the wall material with a large variety of techniques, have produced many valuable derivatives and have attempted, without success, the synthesis of a similar substance from the elements which compose it. Difficulties likewise have arisen in the interpretation of the many types of membrane behavior thus encountered.

Recent investigations of Wanda K. Farr and Sophia H. Eckerson, of the Boyce Thompson Institute for Plant Research, have led to a new conception of cell wall structure. The building up of the wall from small ellipsoid granules of cellulose surrounded by a glue-like substance has been observed in the living cell. The "cellulose particles" are joined together in a single row, end to end, to form a fibril and the fibrils in turn are joined laterally to form each layer of the wall. The particles constitute the crystalline and the cementing material the non-crystalline portions of the membrane. When the cell wall is immersed in water the particles themselves are not affected but are seen to be pushed apart by the swelling of the colloidal cementing material. The fine structure of the cell wall is therefore visible instead of invisible. The separated particles exhibit all the specific properties of cellulose, and the separated cementing material proves to be a jelly-like substance similar to the pectic material which is extracted from citrus fruits and apples. The reactions of the two separable wall constituents are remarkably consistent. It is not difficult to demonstrate that many of the inconsis-



CELLULOSE PARTICLES

a. In a living cell. b. From the wall of a cotton fiber. c. d. A single particle and a disintegrating cotton fiber in polarized light.

tencies of past analyses of entire cell walls have been the result of mutual contamination. The various problems of cellulose chemistry will be reinvestigated in the light of the results of these observations.

FLUCTUATIONS OF ELECTRICAL POTENTIAL IN THE CORTEX OF THE BRAIN

The human electroencephalogram has recently been studied at the Harvard Medical School by Dr. Hallowell Davis and his associates both from the point of view of the normal, and epileptic individual. Preliminary experiments confirmed the observations of Berger, Adrian and others that fluctuations in

electrical potential of as much as 50 microvolts could be recorded from the human head with skull and scalp intact, and also that this activity does not originate in skin or muscle, but in the cortex of the brain. The commonest recognizable pattern is a series of regular waves at a frequency of about ten a second. This pattern, sometimes known as the "alpha" rhythm, is best seen when the subject is physically and mentally at ease with eyes closed. It is suppressed, temporarily at least, by opening the eyes, or by any sensory stimulation or mental activity which sharply engages the subject's attention. Many subjects show it rarely, if at all, even under the most favorable conditions. Other waves of various amplitudes, sometimes at regular frequencies of about 20 to 30 per second (the "beta" waves) and sometimes quite irregular, also appear, either with or without the "alpha" waves. In general, the pattern of activity taken over a period of time from a given area of the skull is characteristic of a given individual.

A number of states involving more or less complete impairment of consciousness, such as fainting, anesthesia and early sleep, show first a loss of the ten-a-second rhythm and then the development of longer and larger waves, sometimes quite regular at about two or three a second.

Epilepsy shows very characteristic patterns. *Petit mal* in particular yields, during the seizure, a very regular series of large waves at the frequency of three a second, each wave accompanied by one or more sharp spikes. The details depend on the individual and on the region of the brain examined, but the general pattern is so highly characteristic of *petit mal* as to be a useful aid in diagnosis. Minor "seizures" with little or no external manifestation may be detected, and the modifications produced by sleep, mental activity, drugs, etc., readily ascertained. A report of such studies was presented at the American Medical Association in Kansas City in May, 1936.

Grand mal epilepsy also presents a characteristic pattern of intense electrical activity building gradually to a climax and then subsiding. This pattern is very similar to the electrical "storms" which may be induced experimentally in certain animals by convulsant drugs or mild damage to the cortex. The latter phenomenon has been described in some detail by Fischer and by Kornmueller in Germany.

The electroencephalogram seems to hold great promise for the physiologist and for the psychologist in the study of normal function and for the neurologist in the study of epilepsy and other abnormal conditions, and work is actively in progress along these lines in many laboratories both in this country and abroad.

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